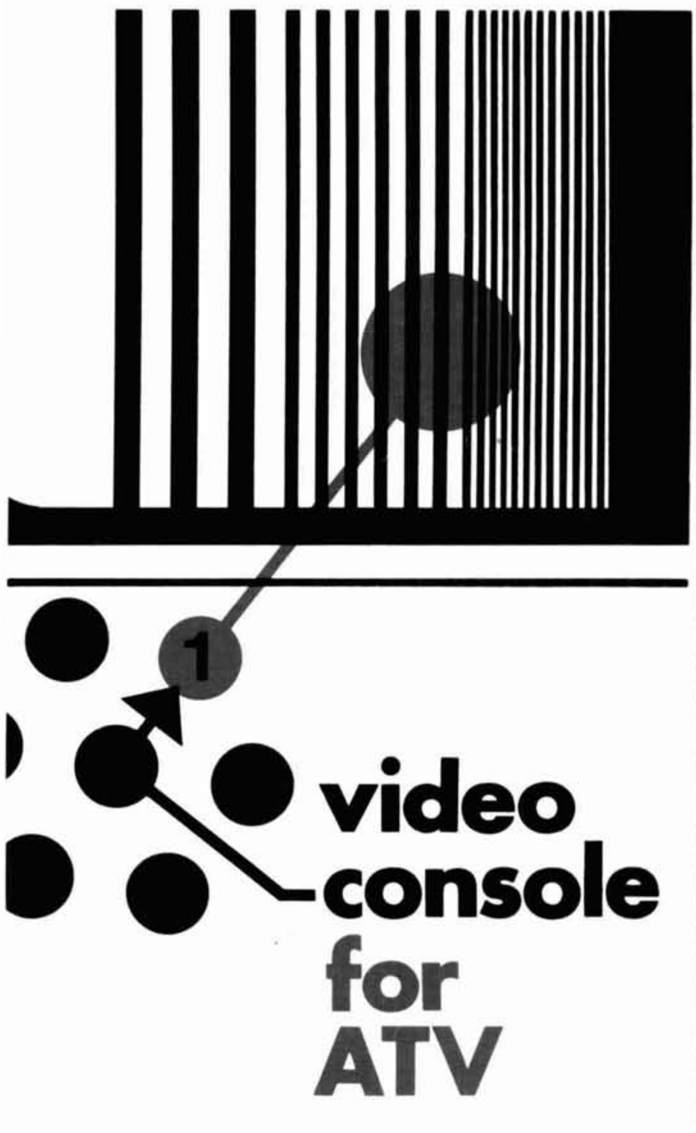
$2.00

ham radio magazine

JANUARY 1980



More Details? CHECK—OFF Page 110

NEW MFJ-525 RF SPEECH PROCESSOR

True RF Speech Processing. Gives you up to 4 times (6db) more average SSB power on all bands. Powerful natural sounding speech punches thru QRM. Works with any rig. Plugs between mic and rig. VU meter. Uses advanced digital and analog techniques.

Powerful natural sounding processed speech punches thru QRM.

Plugs between mic and rig. No internal connections to rig.

$119^{95}

The MFJ-525 gives you up to four times (6db) more average SSB power on all bands with true RF Speech Processing.

Powerful natural sounding speech punches thru QRM and DX pile ups.

Used with your rig, the MFJ-525 gives you more average SSB power increase per dollar than a linear or beam.

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Ideal for mobile and QRP. Vastly improves phone patching. Eliminates flat-topping, splatter.

The MFJ-525 is a closed SSB transmitter-receiver system. Using high performance digital and analog techniques, microphone audio is converted to SSB, clipped and filtered and then converted back down to audio for your rig's mic input.

Use any rig and microphone. Plugs between your mic and rig. No internal connections needed.

Two color VU meter aids in setting clipping level.

Clipping level control sets amount of processing.

Output level control adjusts level to transmitter and eliminates readjusting rig's mic gain control when processor is bypassed.

Push button ON-OFF/BYPASS switch bypasses processor in OFF position. LED indicates power on.

4 pin mic jack. Shielded output cable has push-to-talk line. Uncommitted 4 pin mic plug supplied. Easily adapted for any rig.

RFI protected with double sided PC board ground plane, input, output RFI filtering, ferrite beads, careful layout, RFI coating on side panels.

110 VAC or 12 to 18 VDC. Eggshell white with walnut grain sides. 6x2x6 inches.

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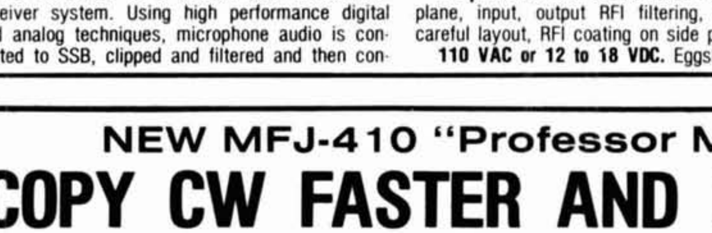
NEW MFJ-410 "Professor Morse" lets you . . .

COPY CW FASTER AND UPGRADE QUICKER

NEW MFJ Random Code Generator/Keyer sends unlimited random code in random groups for practice. Never repeats same sequence. Tailor level to your ability. Vary speed 5 to 50 WPM. Vary spacing between characters. Speed Meter. Full Feature Keyer.

Sends unlimited random code. Never repeats same sequence.

Tailor level to your ability. Vary speed 5-50 WPM.



$149^{95}

Copy code faster and upgrade quicker. Now you can tailor the level of code practice to your exact needs. Practice copying code anywhere and anytime you have a spare moment. Practice at home, in bed, driving to work, during lunch, etc.

The new MFJ-410 "Professor Morse" is a computer-like random code generator and keyer that sends an unlimited supply of precision Morse Code in random groups.

It never repeats the same sequence so you can't memorize it like code tapes.

Vary speed 5-50 WPM and read on speed meter.

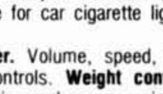
Vary spacing between characters and character groups (for example, copy 5 WPM with 13 WPM characters) to give proper character sound at low speed.

Select alphabetic only or alphanumeric plus punctuation (period, comma, question, slash, double dash.)

Tone control. Room filling volume. Built-in speaker. **Ideal for classroom teaching.** Earphone jack (2.5 mm) for private listening.

Uses 110 VAC, or 9-18 VDC, or 4-C cells (for portable use). Optional cable for car cigarette lighter ($3.00). 6x2x6 inches.

Built-in full feature keyer. Volume, speed, internal tone and weight controls. **Weight control** adjusts dot-dash space ratio; makes your signal distinctive to penetrate QRM. Speed meter works for keyer, too. Tune switch keys transmitter for tuning. Reliable solid-state keying: grid block, cathode, solid state rigs. **OPTIONAL BENCHER IAMBIC PADDLE.**



Dot and dash paddles have fully adjustable tension and spacing. Heavy base with non-slip rubber feet eliminates "walking". $39.95.

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Call 601-323-5869 for technical information, order/repair status. Also call 601-323-5869 outside continental USA and in Mississippi.

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More Details? CHECK—OFF Page 110

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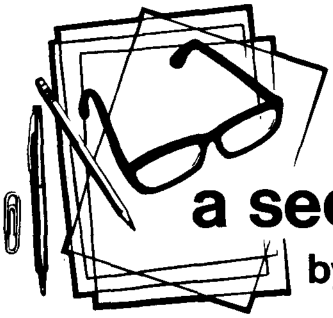
contents



a second look

by Jim Fisk

Are you thinking about buying one of those new solid-state, phased-locked rigs with digital readout? If you are, be sure you buy a rig with a good solid *factory-backed* warranty! As some buyers have sadly discovered, there are *some* Amateur Radio equipment manufacturers who require their dealers to provide the warranty as part of their "dealer agreement;" and in some cases the manufacturer or supplier does not reimburse the dealer for his warranty work. Under such arrangements it doesn't take much imagination to understand why the dealers aren't particularly enthusiastic about fixing faulty equipment. The dealer is further hampered by the unavailability of up-to-date service information — his technicians often have little more available to them than whatever information is packed with the equipment.

I won't dispute the fact that if you had a problem with your equipment you would be able to get it repaired. You probably could; but it might be a long drawn out affair, depending on the dealer you're working with and how much interest he has in doing the factory's warranty repair work with no reimbursement for his parts.

In this day and age of sophisticated equipment the dealers and repair technicians must stock many, many different components for each item they are called on to service. If the dealer is not reimbursed for his time and labor, it's obviously not in his best interest to tie up vast amounts of cash in spare parts — he simply orders the repair parts as he needs them, and you have to wait weeks — perhaps months — before you can get your transceiver back on the air.

Under such circumstances shipping your rig back to the factory for repair may be the best move you can make. They have all the parts and expertise to do it right, and in many cases they can give you better "turn around" than your local dealer. This is not a criticism of your dealer's repair facilities; his technicians must be familiar with many different types of equipment, whereas the factory technicians are able to specialize and hence can often do the job faster.

As a final note, any equipment manufacturer who does not offer factory repair facilities is suspect — they are simply passing the buck down the line to the dealer. And you know who suffers in the long run!

Most of the Amateur Radio manufacturers, fortunately, offer full factory-backed warranties, but those who do not should be avoided like the plague. Keep that in mind before you plunk down your hard-earned dollars for a new rig.

Jim Fisk, W1HR
editor-in-chief

6 Meters + ICOM + Sunspots = The best DX

ICOM's 551D is Essential to the 6 mtr DX Formula.

The IC-551D is the high powered brother to the ICOM IC-551. With an 80+ watt output, you have all the punch you need for that really good DX when the Sunspots are working for you. The 551D has the same no-backlash, no-delay dual VFO light chopper system, coupled to the microprocessor for split frequency as well as completely variable offsets.

For quick access to DX excitement, three memories are provided for programmed beacon watching, which can be scanned and programmed to stop on the first one heard. A room full of white noise is no longer a problem with ICOM. Pass band tuning and VOX are included at no extra cost.

SPECIFICATIONS

Frequency Coverage: 50~54MHz

Power Supply Requirements:
13.8V DC±15%, negative ground
Current drain 18A max.
(at 200W input). AC power supply speaker console is available for AC operation.

Emission Modes:
A3J SSB (USB/LSB)
A1 CW
A3H AM
F3* FM

Dimensions: 111mm (H)× 241mm (W)×311mm (D)

Weight: 6.6kg

Sensitivity: SSB/CW/AM
Less than 0.5μV for 10dB S+N/N
FM* More than
30dB S+N+D/N+D at 1μV

Squelch Sensitivity: SSB/CW/AM 1μV
FM* 0.4μV

Selectivity: SSB/CW/AM
More than ±1.1 KHz at -6dB
Less than ±2.2KHz at -60dB
Adjustable to 1KHz at -6dB
FM*
More than ±7.5KHz at -6dB
Less than ±15KHz at -60dB

*Only when FM Unit is installed.

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Please send me: ☐ IC-551D specifications sheet; ☐ full color ICOM Product Line Catalog; ☐ List of Authorized ICOM Dealers.

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You may send a machine copy of this form

All stated specifications are subject to change without notice. All ICOM radios significantly exceed FCC regulations limiting spurious emissions.

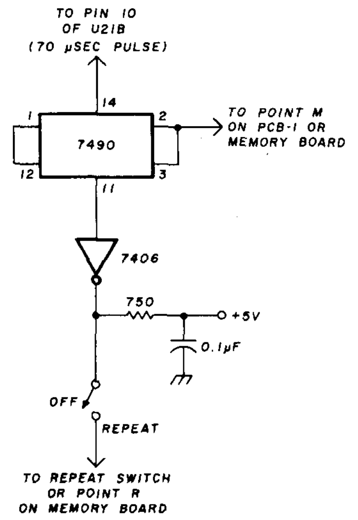
comments

W7BBX memory keyer

Dear HR:

I have used the W7BBX memory keyer* with great success. Compared with the WB4VVF memory keyer (built by SP5JC) and other designs described in the European ham magazines, the W7BBX circuit is definitely the best. I would like to tell your readers of a small addition to the existing circuit which is especially valuable in meteor-scatter (MS) communications.

One inconvenience in the unmodified keyer is the necessity to completely fill the memory, because any empty memory space will show up as breaks in transmissions with repeated messages; such transmissions are used a great deal in MS operations. I used to try to completely fill the memory, but with some callsigns and reports used in MS it was not always possible. Then you would either lose valuable time by sending nothing, or push the REPEAT button every few seconds, depending on the speed. The last method leaves no time for other aspects of MS work, such as listening through the recorded tapes at reduced speed while your keyer does the transmission sequence. I decided to add a circuit which senses the end of a message stored in the keyer memory and automatically REPEATS the message. The circuit is very simple and can be built on a small add-on PC board and wired into the existing boards either above or between them. One additional switch on the front panel is necessary for switching the circuit in or out of operation, as shown below.



I also added a switch with a bank of multiturn precision adjustable potentiometers, each for a preset high-speed value. Using the original 2.2-μFd tantalum capacitor for C4 and 180 ohms for R6, I can use any speed up to 1000 letters per minute (LPM) simply by choosing the position of the speed switch, which replaces the original speed pot. One speed switch position switches in a multiturn pot with dial for "normal" variable-speed operation at conventional speeds. There are no keyer problems with transmission speeds up to 1000 LPM (higher speeds were not tried), but the time constants in the transmitter keying circuit should be carefully checked to ensure proper operation on the air. I'm using 5k and 20k pots for the preset speed trimmers; in Europe we use speeds around 500-700 LPM for MS, depending on the available speed reduction in the recorders at the other receiving end.

Another valuable feature of the W7BBX keyer is the remote start facility; I'm now using a pulse from the station electronic clock, which gives a pulse every 15 seconds, 30 seconds, 1 minute, or 5 minutes (the latter is still the most common transmit/receive sequence in European MS operation to handle the timekeeping). I now have plenty of time during a MS QSO, whereas before I had to be constantly on the alert, checking tapes, and looking at the clock.

Wes Wysocki, SP2DX
Gdansk, Poland

*Howard Batie, W7BBX, "Programmable Contest Keyer," *ham radio*, April, 1976, page 10.

low-power wattmeter

Dear HR:

I recently built my own version of the low-power wattmeter described by WA4ZRP in the December, 1977, issue of *ham radio*. The electronics perform very well — I eliminated the need for carefully measuring the calibration resistors to 0.001 ohm by using 500-ohm trimpots with parallel and/or series resistors to make up the required ranges.

The key to the design, however, is the subminiature lamps. I was unable to find the correct voltage and current ranges for the stated *generic* types T 3/4 and CM units listed by the author. For those who have built similar units and have had difficulty finding the barreter lamps, the Sylvania 28ES will do (rated at least 28 volts and 40 mA with a resistance of 80 ohms); however, these lamps are somewhat large, as they're rated at 1.2 watt.

It may be possible to locate some of the subminiature 3-volt, 30-mA lamps, but you must first know the rated value of dc resistance (it is *not* voltage divided by current). I have sought this information from Chicago Miniature Inc. (who make the CM units mentioned in the article), but have had no response to date.

Gene Shapiro, WØDLQ
Leawood, Kansas

A Knob with a new twist "VRS™"

Swan Astro 150 Exclusive Microprocessor Control w/memory gives you over 100,000 fully synthesized frequencies, and more!

- VRS — Variable Rate Scanning, a dramatic new technique for unprecedented tuning ease and accuracy
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Dual Meter
Reads PEP output in watts and receive "S" units.

Full Break-in CW
(or semi, switch selected)

Wide Frequency Coverage
10M — 28.0-30.0 MHz
15M — 20.8-23.0 MHz
20M — 13.8-16.0 MHz
40M — 6.0-8.3 MHz
80M — 3.0-4.5 MHz
160M — 1.8-2.4 MHz*
*in lieu of 10M band on Model Astro 151

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For accurate 100 Hz steps or fixed rate scan.

PSU-5 Power Supply with Speaker
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THE MOST ADVANCED HF SSB TRANSCEIVER AVAILABLE.

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presstop

WARC results favorable to Amateur Radio

ALL PRESENT HF BANDS, THREE NEW HF BANDS, and a new UHF band were allocated to the Amateur Service as WARC 79 finished its work December 4. Despite some gloomy predictions of a major frequency loss by the Amateur Service, it's now been confirmed that Amateurs — at least in the U.S. — did not lose one kHz in the HF spectrum but instead picked up all three of the desired new bands! In the VHF spectrum preliminary press-time reports, believed complete and accurate, show equally good news for higher frequency enthusiasts. Band by band, here's the rundown from WARC 79 on the new Amateur spectrum through 1000 MHz.

160 Meters: In Region 1, 1800-1850 shared with Loran until Loran shuts down at the end of 1982, 1850-2000 shared with Fixed, Mobile, Radio Location and Radio Navigation (1850-2000 not available for Amateurs in Mexico and much of South America). 1800-1850 will be available to Amateurs in Region 1 for the first time, on a shared basis with Loran until its shutdown.

80/75 Meters: In Region 2, 3500-3750 Amateur Exclusive with the exception of Mexican and some South American Fixed and Mobile users, 3750-4000 shared with Fixed and Mobile — except for much of southern South America, which excludes Amateurs 3750-4000, and Canada and Greenland, which reserve 3950-4000 for a future Arctic region broadcast service on a non-interference basis.

40 Meters: 7000-7100 Amateur Exclusive worldwide, 7100-7300 Amateur in Region 2 only with the stipulation that Region 2 Amateur operation must not interfere with broadcast in Region 1 or 3.

30 Meters (new band): 10.10-10.15 MHz with Fixed Service Primary and Amateur Service Secondary, worldwide.

20 Meters: 14.00-14.35 unchanged, with several others joining Russia in footnotes reserving 14.25-14.35 for Fixed Services.

17 Meters (new band): 18.068-18.168 Amateur and Amateur Satellite are Exclusive (with a Russian reservation for internal Fixed Service use), but with the stipulation that Amateurs won't be permitted to move in until after all present users have moved!

15 Meters: No change, worldwide.

12 Meters (new band): 24.890-24.990 Amateur and Amateur Satellite are Exclusive, with the same restrictions as 17 Meters.

10 Meters: Unchanged, worldwide.

6 Meters: Unchanged, after earlier hope of some limited band being made available in Region 1 didn't materialize.

2 Meters: Unchanged (144-148 in Region 2, 144-146 elsewhere).

1¼ Meters: Amateur in Region 2 only, co-shared with Mobile and Fixed on an equal basis.

70 Centimeters: 430-440 MHz has Radio Location Primary, Amateur Radio Secondary in all Regions, with 435-438 Amateur Satellite. 420-430 and 440-450 shows Fixed and Mobile Primary in all Regions, but a footnote by the U.S. and several others allocates these additional frequencies to the Amateur Service on a Secondary basis. Similarly, 440-450 is allocated to Amateurs on a Secondary basis in a footnote by Canada and several others.

35 Centimeters (new band): A new UHF 902-928 MHz band, was allocated to Fixed, Mobile, ISM and others on a shared, Primary basis, with the Amateur Service Secondary. What this means to the Amateur Service in the U.S. is hard to predict, with interest high at the FCC in a new Personal Radio Service in this band.

Details On Amateur Microwave allocations were not available at press time, though it's almost certain that 1215-1300 saw some reduction. We should have a detailed rundown on the higher frequencies next month. There's no need to rush up any new antennas, as action on WARC results is probably a year or more away and implementation of frequency table changes even further off!

HANDICAPPED PROSPECTIVE AMATEURS won't be given special CW or written exams, the Commission decided recently in a session that held many implications for future Amateur rules. During the discussion there were several comments that CW was no longer much used by Amateurs, and Chairman Ferris suggested that since CW no longer seemed relevant to Amateur activities it should be dropped from the requirements for all Amateurs, not just the handicapped! As a result of this discussion there appears to be a distinct possibility that the commission could be planning to drop CW requirements above 144 MHz, in accordance with present ITU Article 41, and later implement further relaxations in line with the final WARC position on Amateur CW.

The Amateur Satellite Service was also discussed in the same commission meeting. After considerable discussion the go-ahead was given for a Notice of Proposed Rule Making to establish rules for Amateur satellite operation, based on present ITU Amateur satellite rules and the experience of AMSAT and the FCC with OSCARs 6, 7, and 8.

AMATEUR LICENSING AND RFI are both well covered in a draft of Senator Goldwater's Communications Act rewrite that's currently being circulated by Republican members of the Senate Communications Subcommittee. Under the proposed draft, which is being prepared for introduction early in this year's session, Amateur license terms would be extended to 10 years and the FCC could "use licensed Amateurs to administer license examinations and grant temporary licenses." The FCC would also have "the authority to require protective circuitry in consumer electronic equipment." Also covered in the draft is the subject of license fees.

THE OMNI SYSTEM — tools of the trade for serious DX operators, contesters, traffic, nets, or just rag chewing — designed to give you the operating edge.

Simply Super. The keynote of a Ten-Tec OMNI is simplicity of operation combined with super performance. No tricky controls, no distracting readings, no fussy adjustments. Your operating is pure enjoyment, unhampered by complexity, enhanced by features that are meaningful, advanced by options that are realistic.

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Full Break-In—for CW with perfect timing, for a real conversation in code. And slow break-in at the flip of a switch to suit band conditions or quiet mobile operation.

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Variable Notch Filter—to eliminate interfering carriers and CW signals. Attenuation is more than 8 "S" units (over 50 dB).

Six-Function Separate VFO—for complete versatility in working DX. Independent transmit and receive frequencies with OMNI; reversible at the touch of a button for full monitoring of the action. Even allows simultaneous reception on both VFO and OMNI with transmission on either. LEDs show status. An optional operating bargain at $139.

Speech Processor and Microphone—to extend your operating range under adverse conditions by increasing average envelope power without derating the OMNI power limits and with minimum distortion. Model 234 is a true RF processor, model 214 is a peak-free condenser microphone. An optional system for optimum speech energy; 234 is $124, 214 is $39.

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Model 545 Series B OMNI-A (analog transceiver) **$ 949**

Model 546 Series B OMNI-D (digital transceiver) **$1119**

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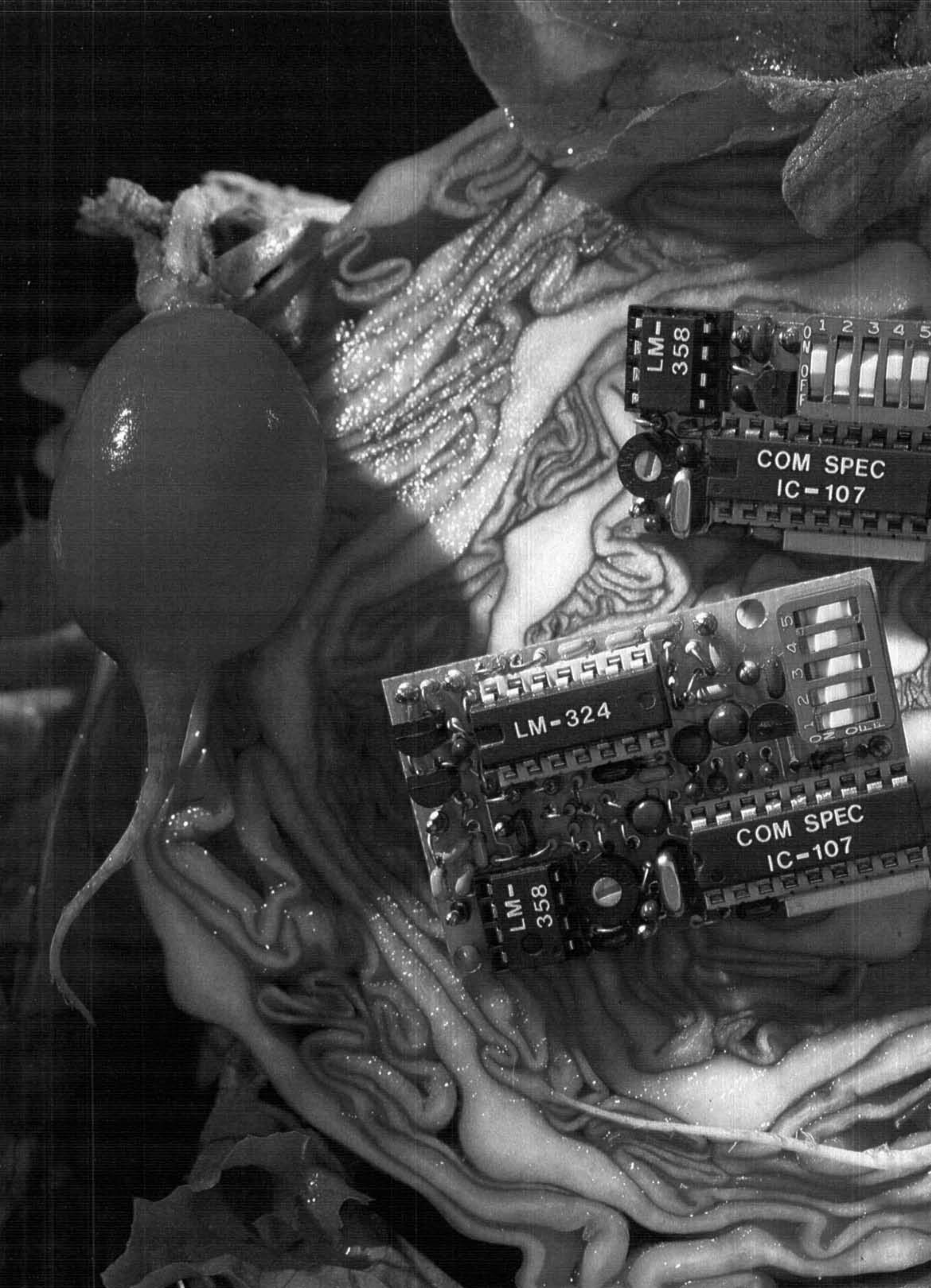
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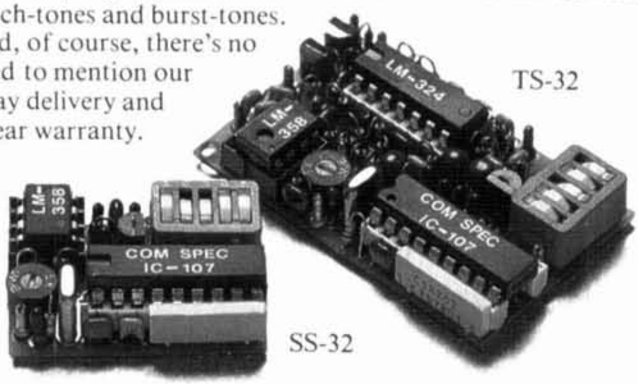
A fresh idea!

Our new crop of tone equipment is the freshest thing growing in the encoder/decoder field today. All tones are instantly programmable by setting a dip switch; no counter is required. Frequency accuracy is an astonishing ± .1 Hz over all temperature extremes. Multiple tone frequency operation is a snap since the dip switch may be remoted. Our SS-32 encode only model is programmed for all 32 CTCSS tones or all test tones, touch-tones and burst-tones.

And, of course, there's no need to mention our 1 day delivery and 1 year warranty.



TS-32

SS-32

TS-32 Encoder-Decoder

- Size: 1.25" x 2.0" x .40"
- High-pass tone filter included that may be muted
- Meets all new RS-220-A specifications
- Available in all 32 EIA standard CTCSS tones

SS-32 Encoder

- Size: .9" x 1.3" x .40"
- Available with either Group A or Group B tones

Frequencies Available:

Group A			
67.0 XZ	91.5 ZZ	118.8 2B	156.7 5A
71.9 XA	94.8 ZA	123.0 3Z	162.2 5B
74.4 WA	97.4 ZB	127.3 3A	167.9 6Z
77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

- Frequency accuracy, ± .1 Hz maximum − 40°C to + 85°C
- Frequencies to 250 Hz available on special order
- Continuous tone

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TEST-TONES:	TOUCH-TONES:		BURST-TONES:			
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1000	770	1336	1650	1900	2200	2450
1500	852	1477	1700	1950	2250	2500
2175	941	1633	1750	2000	2300	2550
2805			1800	2100	2350	

- Frequency accuracy, ± 1 Hz maximum − 40°C to + 85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

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video console for ATV

A project for Amateurs interested in improving their fast-scan television stations — three video generators, a special-effects generator, and a simplified form of Gen-Lock are described

The video console project began after I'd completed a solid-state ATV transmitter. I had no way of knowing how it was performing except by having other ATVers try to "talk me in" on alignment. I soon learned this was almost impossible.

I discussed my problem with Bill Parker, W8DMR, another ATV ham, and he suggested that I needed a few test generators. So I consulted *A5* magazine and found articles on two generators.[1,2] After running some tests and reading a book by Tektronix,[3] I found a need for one more generator so that I could check 99 per cent of my new transmitter. I then designed a pulse and bar generator. After this I thought, "Boy, wouldn't it be nice to have some special effects, such as a video switcher." After a short time I had it operational.

the video console

The video console consists of three function generators, a video switcher, and a Glen-Lock circuit. All can be locked to either external or internal sync or to a composite video signal. Everything is contained on five PC boards and powered by a single 12-volt supply.

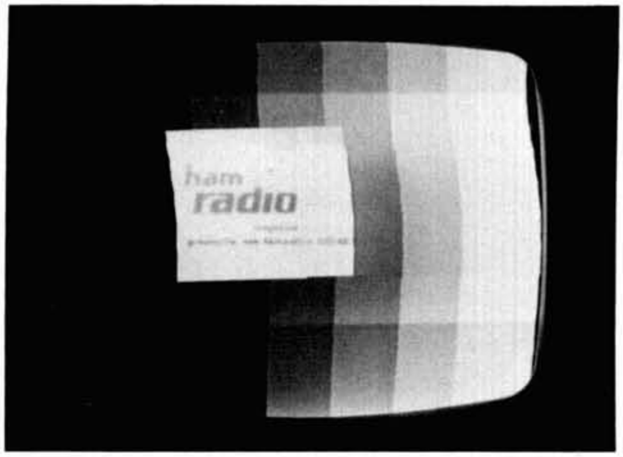
The function generators are multiburst, gray scale, and pulse and bar. The multiburst generator creates a frequency-burst pattern on the TV screen of white to the extreme left followed by a low-frequency signal of 0.5 MHz, then 1.7 MHz and 3.4 MHz signal. The extreme right of the TV screen shows a 4.5-MHz burst frequency (see **photo D**).

The multiburst generator can be used to check bandwidth of video equipment such as amplifiers, TV transmitters and tape recorders. It can also be used with oscilloscopes. Just insert the multiburst generator output into the input of the equipment under test and look at the results on the TV screen or on an oscilloscope (see **photo E**). **Photo F** shows high-frequency rolloff, and **photo G** shows the middle frequencies with too much gain. These test patterns depict only a few of the results, but **photo E** is the best example.

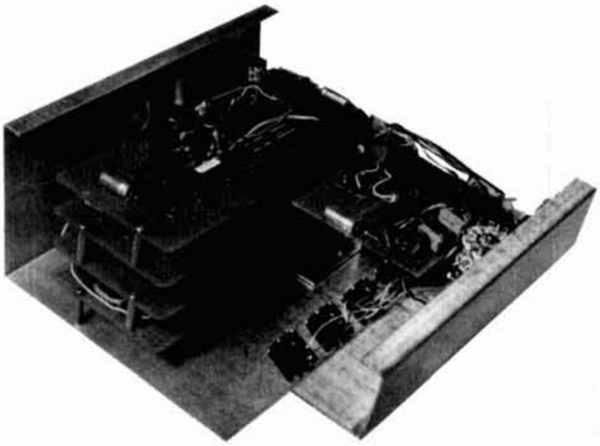
The second generator is a gray-scale (staircase) generator. It produces a pattern on the TV screen, as seen in **photo H** from left to right, in seven shades of gray. The staircase generator is used to check your video-system linearity. It shows if the white or black video is being compressed (see examples in **photos I** and **J**). If you insert the gray-scale generator into a video modulator or other video input, you should see a gray scale as in **photo H**. If you look at the gray-scale generator output on the oscilloscope, you'll see a staircase pattern as in **photo K**.

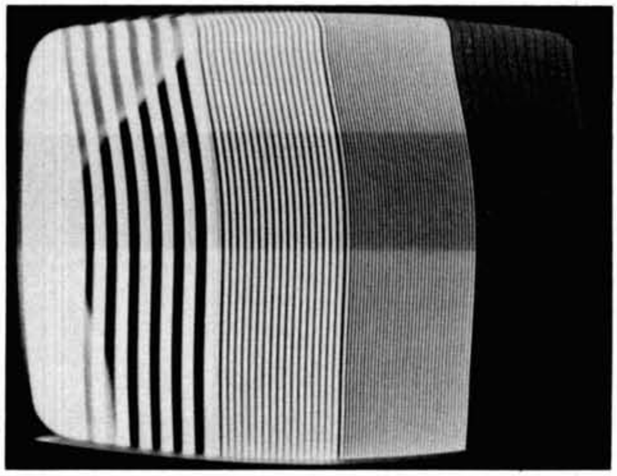
The third generator is called a "pulse and bar." It produces a white pulse on the left-half, and a white box in the right-half, of the TV screen. Its function is to check for high- and low-frequency bandpass characteristics. The pulse and bar generator output as seen on the TV screen is shown in **photo L**. On an

By Charles A. Beener, WB8LGA, 2548 SR 61, Marengo, Ohio 43334



Photos A and B: Special effects that can be generated by the video console. Photos by WB8HXR.





Photos C and D: Inside view of the video console, left. At right, multiburst generator output as seen on TV screen.

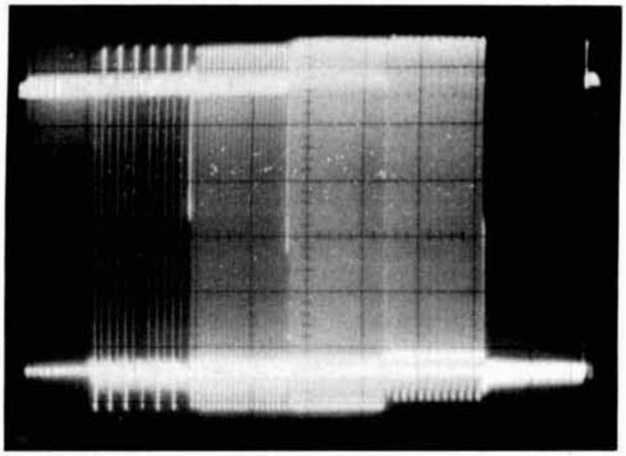
oscilloscope, you see a wave form as shown in **photos M** and **N**.

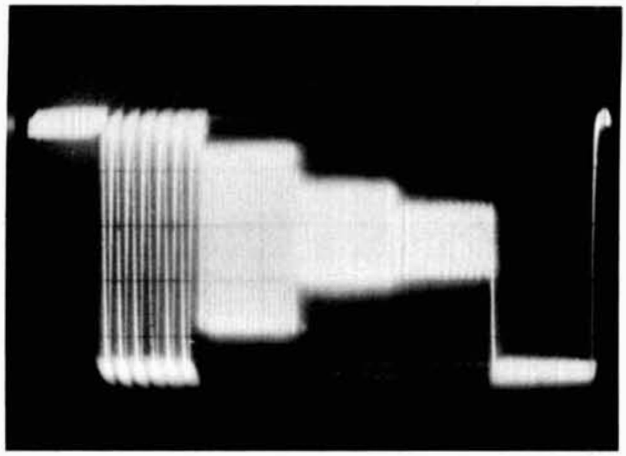
circuit description

The following is a description of the five circuits that compose the video console. They consist of the multiburst generator (A1 board), gray-scale generator (A2 board), pulse and bar generator (A3 board), video switcher (A4 board), and Gen-Lock (A5 board).

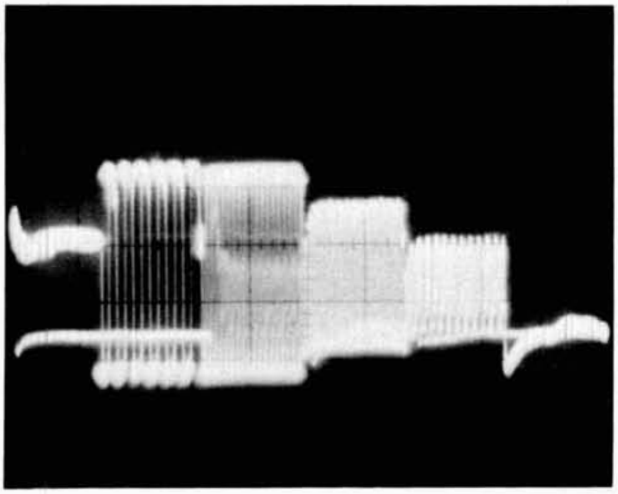
Multiburst generator (A1 board). This circuit is shown in **fig. 1**. Referring to **fig. 1**, U9 is a free-running oscillator whose frequency is 3.402 MHz. U9 drives U1 and U2, a divide-by-three counter with an output frequency of 1.134 MHz. U2A drives U2B, a divide-by-two counter whose output is 0.567 MHz. U2B output drives a divide-by-six counter, U3A, U3B, and U4, whose output frequency is 94.5 kHz. This signal drives a six-stage shift register that shifts the gating from left to right on the screen. The five *H* signals (**fig. 1**) drive the five NAND gates, U8A, B, C, D, and U9C. One section of U1A is fed to U1B, a divide-by-two counter with an output of 1.7 MHz. The same signal is fed to U8D. The output of U2A, 1.134 MHz, feeds U9A, which drives U9C. All U8 and U9C outputs are NANDed into U12. They are controlled by **H1**, **H2**, **H3**, **H4** and **H5**, and are turned on, one at a time, by the 6-stage shift register. The sum results in an output from U12 of the first high signal followed by a 0.567-MHz signal, 1.7 MHz-signal, 3.4-MHz signal, then a 4.5-MHz signa. This occurs in 54μs. This time, plus that of the horizontal sync pulse, is equal to 63.5 μs, which is the time required for one horizontal sync line on the TV screen.

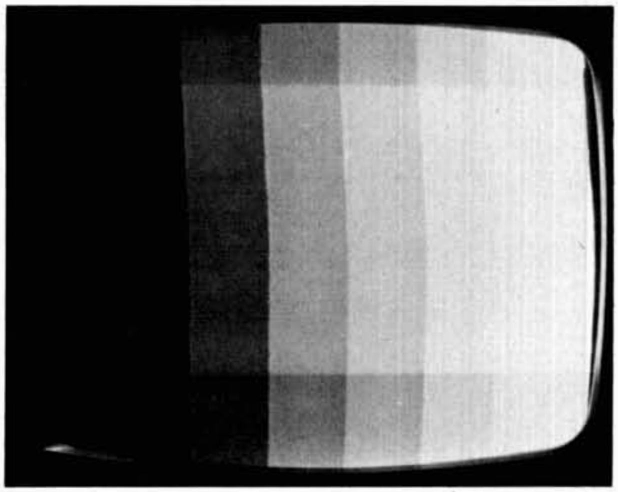
The sequence repeats until a vertical sync pulse appears on U10, pin 1. U10 is a one-shot. U10 provides a 1-ms pulse, which resets the 6-stage shift register at U5A, pin 4. U10 Q output (pin 1) is used for vertical blanking. The output of U7B, pin 6, is a horizontal timing pulse. It is NANDed at U10 pin 1 and is the vertical timing pulse for the composite sync. The



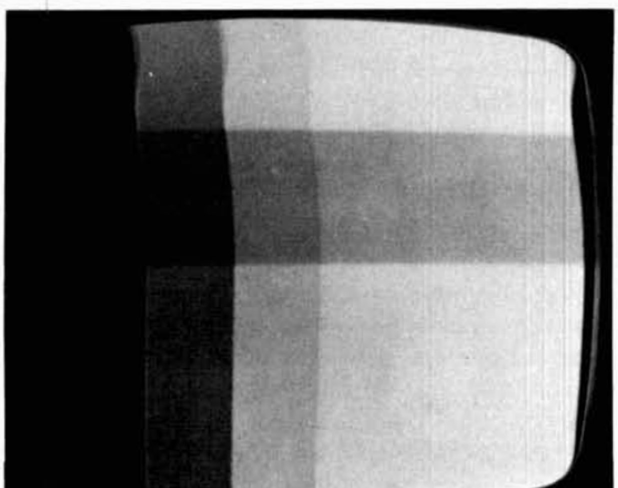


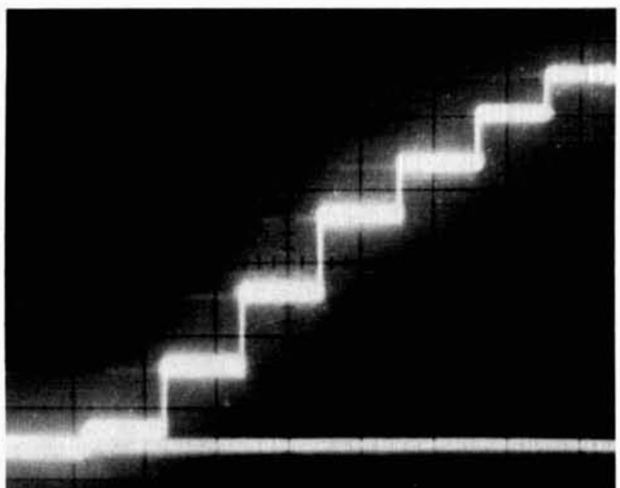
Photos E and F: Oscilloscope test pattern showing output of the multiburst generator, left. At right, multiburst generator test pattern showing high-frequency rolloff.



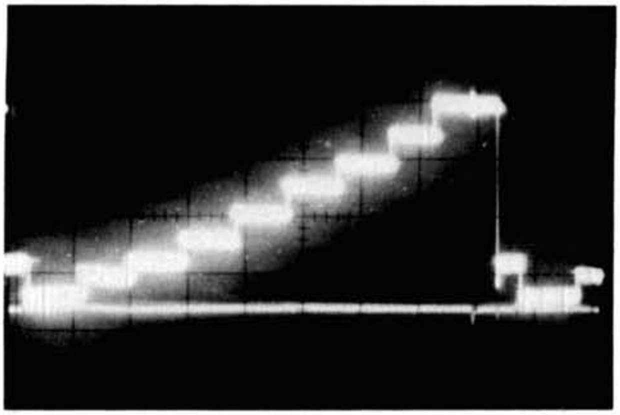


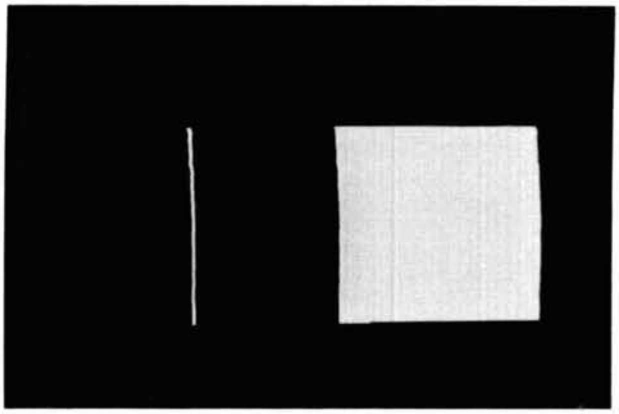
Photos G and H: Another test pattern of the multiburst generator showing excessive gain at the middle frequencies, left. At right, output of the gray-scale (staircase) generator as seen on the TV screen.





Photos I and J: Gray-scale generator output showing white video being compressed on TV screen, left. At right, oscilloscope test pattern showing gray-scale generator output. White video compressed.





Photos K and L: Gray-scale generator output shown on oscilloscope, left. At right, pulse and bar generator output as seen on the TV screen.

composite video outputs appear at R15.

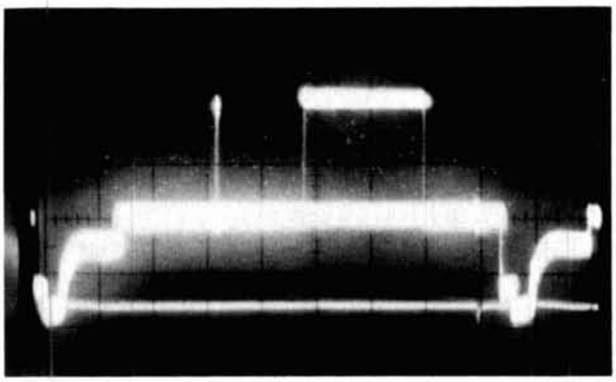
Gray-scale generator (A2 board). The main oscillator is U1 (**fig. 2**). Its frequency, 126 kHz, is determined by C1, R1. U1 output is fed to U2, a divide-by-eight counter. Counter output is NANDed at U1A, which drives U1B. This stabilizes the oscillator by the horizontal sync pulses on U2 pins 2 and 3. (U2 is a decade counter.) Each time the horizontal sync appears on U2 pins 2 and 3, the counter is reset to all zeroes. The three outputs from U2 also drive two hex inverters, whose output provides a staircase at the output. (See **photo K**.)

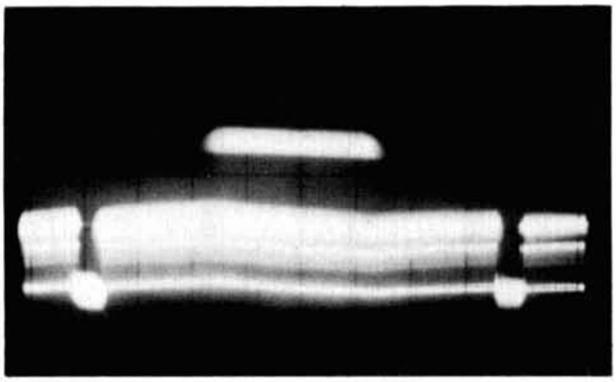
From pin 8 U2 drives U4, pins 3 and 4. U4 is a delay trigger, which drives U5. U5 provides an output 11-μs wide of horizontal sync. The sync and video are mixed by R9 and by R10, which is the video-output pot. The A2 board also contains the oscillators for the horizontal and vertical sync. These are common NE-555 timers, U6, and U7.

Pulse and bar generator (A3 board). The generator works on the principle of the one-shot delay, using 74121s. The horizontal sync feeds U3, U4, U5 **(fig. 2). The time delay is from the horizontal sync** pulse. The amount of delay is determined by the one-shot RC time constant. U3 provides the start of the bar; U4 provides the stop of the bar. U5 positions the pulse on the screen. U3 and U4 outputs drive U1A and U1B, a set and reset latch. This latch output is equal to the bar width.

The vertical sync triggers U6 and U7. U6 and U7 drive a set and reset latch U1C and U1D. U6 delay determines where the top of the pulse and bar signals start. The bottom of the pulse and bar signal is determined by U7. The output of U1D, pin 11, are NANDed together through U2A and U2C. The pulse and bar signals are mixed in R17. Output is obtained through R19. The horizontal sync signal is 4 μs wide and is resistor mixed to make the horizontal sync tips. The same input drives U8, a 11-μs-wide pulse for the horizontal sync front and back porch. It is also resistor mixed through R20.

Video switcher (A4 board). The switcher (**fig. 3**) works almost on the same principle as the pulse and bar generator. U1, U2, U3, and U4 perform the same job as U3, U4, U1, U6, and U7 in the pulse and bar generator. The outputs of U5, pins 6 and 11, are NANDed in U6A. U6A output drives U7B and U6B. U6B is an inverter that drives U7A. In other words,





Photos M and N: Pulse and bar generator output shown in one horizontal time period, left. At right, pulse and bar generator output shown in one vertical time period.

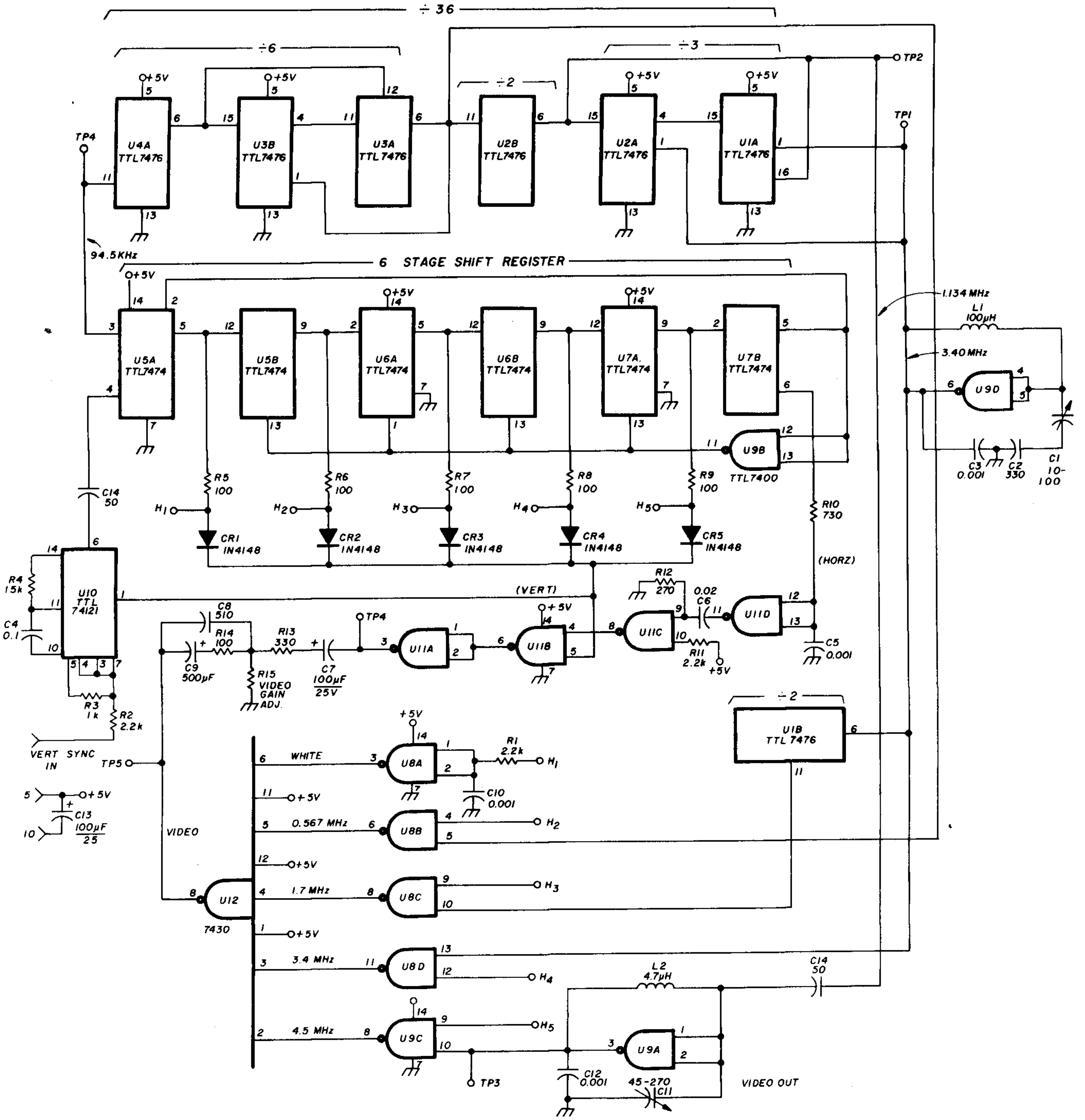
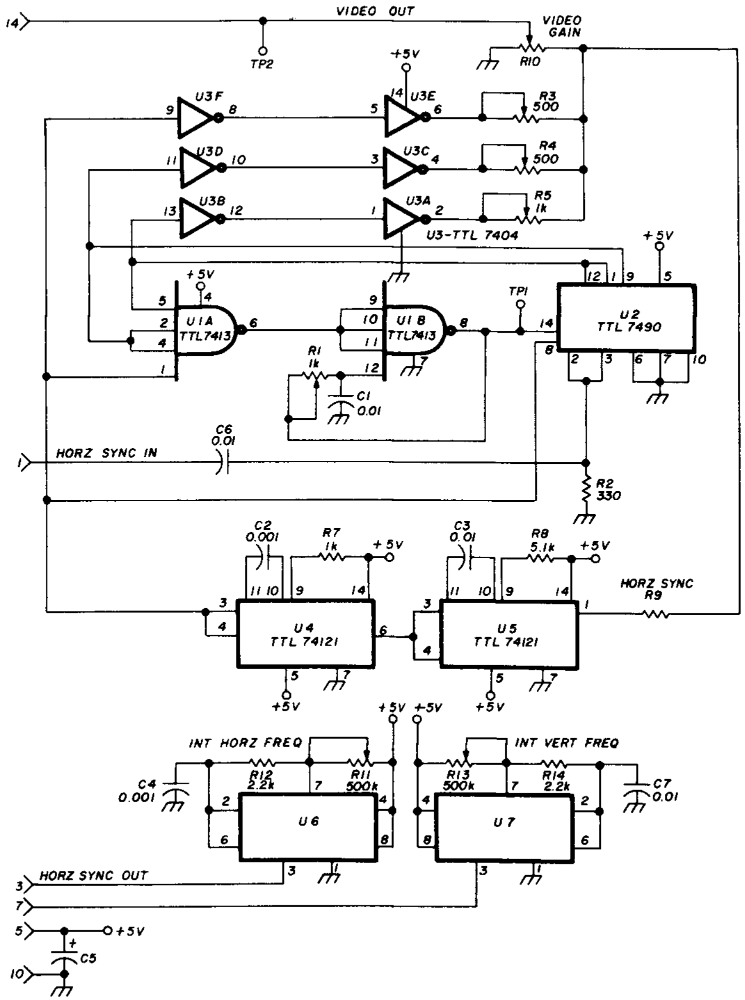


fig. 1. Multiburst generator schematic (A1 board).

only one section of U7 is on at any one time. Window-positioning pots R1-R4 control the vertical and horizontal start and stopping position of the switched video.

The video switcher, U7, is a CMOS IC. A low on pin 5 turns off the switcher between pins 3 and 4. If you put a high signal on pin 5 the switch turns on. Now it acts as if a 300-ohm resistor were placed between pins 3 and 4. (This CMOS IC is a CD 4016, but a CD 4066 can be used.) Switcher U7 outputs are tied together and run into a 74C04 inverter used in linear mode. The output of U7 is positive video to be amplified, so it was necessary to run it through two inverters. The output of a CMOS IC doesn't like a 100-ohm load, so it's buffered with an emitter follower, Q1.



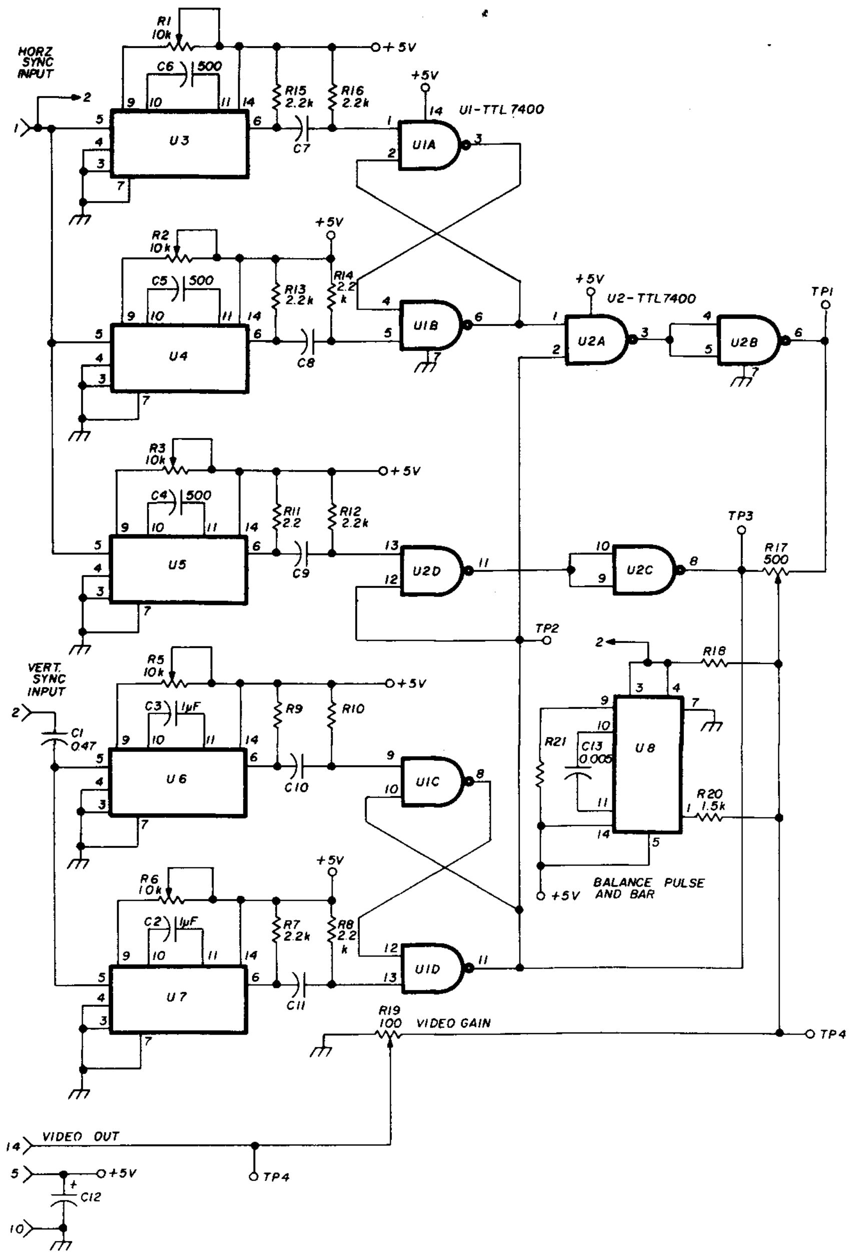


fig. 2. Above: Gray-scale generator schematic (A2 board). At right: Pulse and bar generator schematic (A3 board).

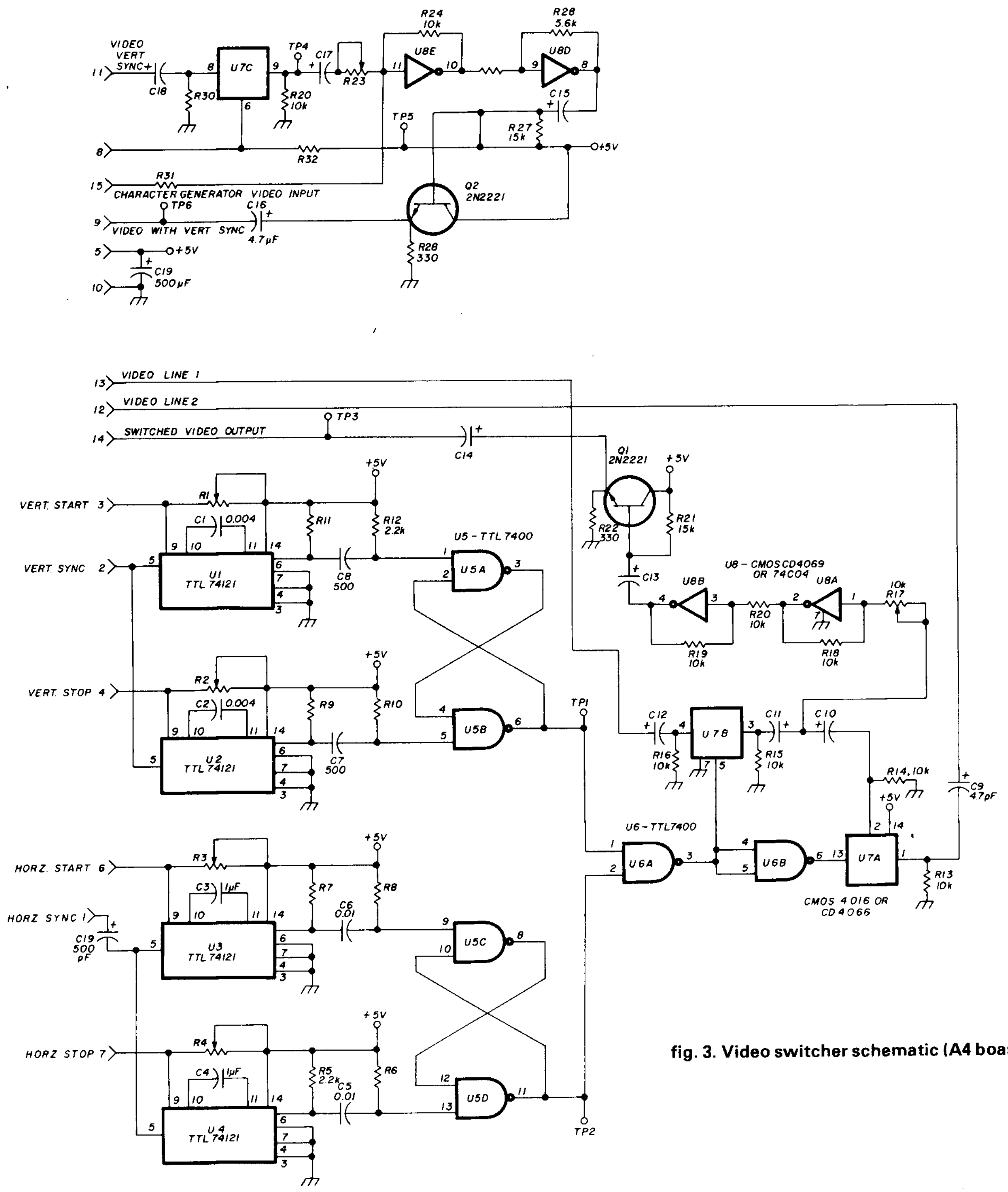


fig. 3. Video switcher schematic (A4 board).

The vertical sync blanker and dc restorer circuit are on the video switcher board. U7C is a switch controlled by the vertical sync pulse. Any video coming in at A4 pin 11 will be blanked during the vertical sync interval. After this, the video is reamplified through U8 and is applied to emitter follower Q2. At the base of Q2, the vertical sync pulse is reinserted to take the vertical base line down to the correct reference. The character generator video input is inserted at U8 pin 11, through R31.

Gen-Lock (A5 board). The video input enters on A5 pin 1 (see **fig. 4**). It drives Q1, a sync stripper. Q1 removes all the video, and only composite horizontal and vertical sync signals remain at the Q1 collector.

The sync signals are run through RC filter R4, C3, C4, R5. The vertical sync drives Q2, an amplifier, whose output is applied to the sync selector on the front panel.

The horizontal sync is applied to U1, a phase-locked loop. The IC is a PLL567, which is tuned for 15,750kHz. This IC is a tone decoder. When it's locked onto an incoming signal, it has a dc output at pin 8. There's also a signal at U1 pin 5. This signal has the same frequency as the incoming signal during lock. U1 pin 5 output is then used as the horizontal sync in the generator and goes to the sync selector switch.

The sync-selector switch output is fed to amplifier Q3 for vertical; Q5 for horizontal. U2 is a Schmitt trigger for fast trigger timing. Q4 is a buffer for the vertical sync. Q4 output drives all the vertical and/or horizontal inputs of boards A1-A5.

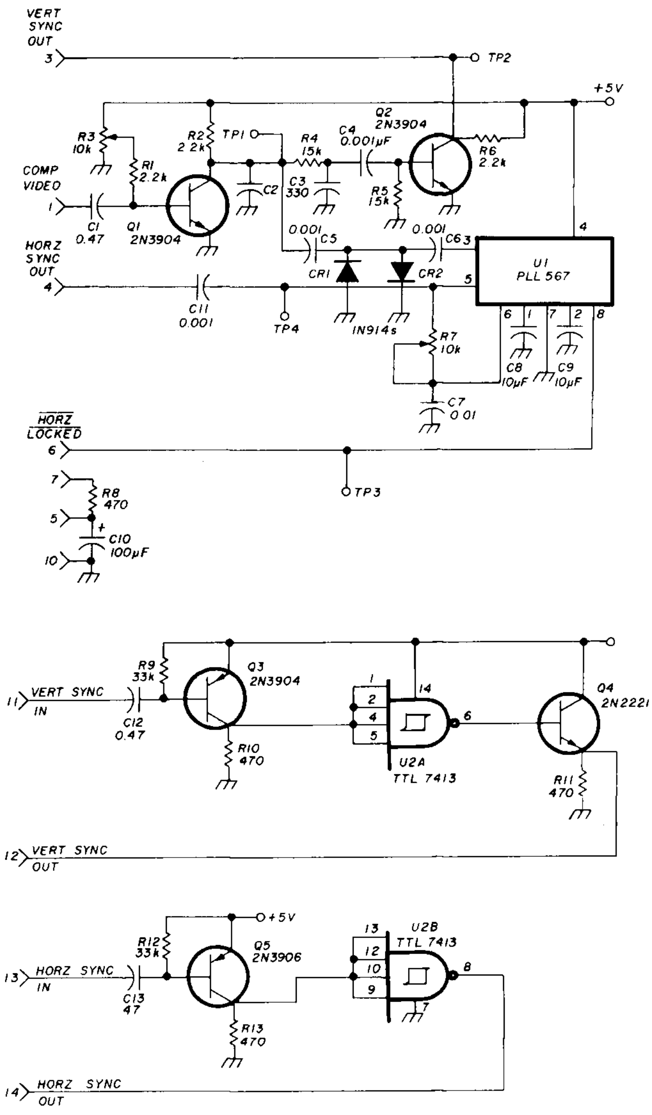


fig. 4. Gen-Lock schematic (A5 board).

interconnections

Fig. 5, the main board, shows how to tie it all together. **A** shows sync-selector switch connections. **B** shows how to interconnect the rotary function-generator switches to the five PC boards. **C** shows the interface between the window-position controls and video switcher/Gen-Lock boards.

adjustments

Multiburst generator (A1 board).

1. Adjust C1 for an output frequency of 3.402 MHz at U9 pin 6 or for horizontal locked sync on TV when video is fed into the TV.

2. Adjust C11 for an output of 4.5 MHz on U9 pin 3.

3. Adjust R15 for video gain. It should be 1-volt p-p at A1, pin 14.

Gray-scale generator (A2 board).

1. Adjust R1 for 126 kHz at test point 1, or for seven shades of gray on the TV screen.

2. Adjust R10 video gain for 1 volt p-p video at test point 2.

3. Adjust R11 for 15,750 kHz at U6 pin 3.

4. Adjust R13 for 60 Hz at U7 pin 3.

5. Adjust R3 for approximately 75 ohms.

6. Adjust R4 for approximately 250 ohms.

7. Adjust R5 for approximately 600 ohms.

8. Adjust R3 = R5 for the best linearity of output video.

Pulse and bar generator (A3 board).

1. Adjust R1 for vertical position of left side of bar on TV screen.

2. Adjust R2 for vertical position of right side of bar on TV screen.

3. Adjust R3 for vertical position of pulse (see **photo L**).

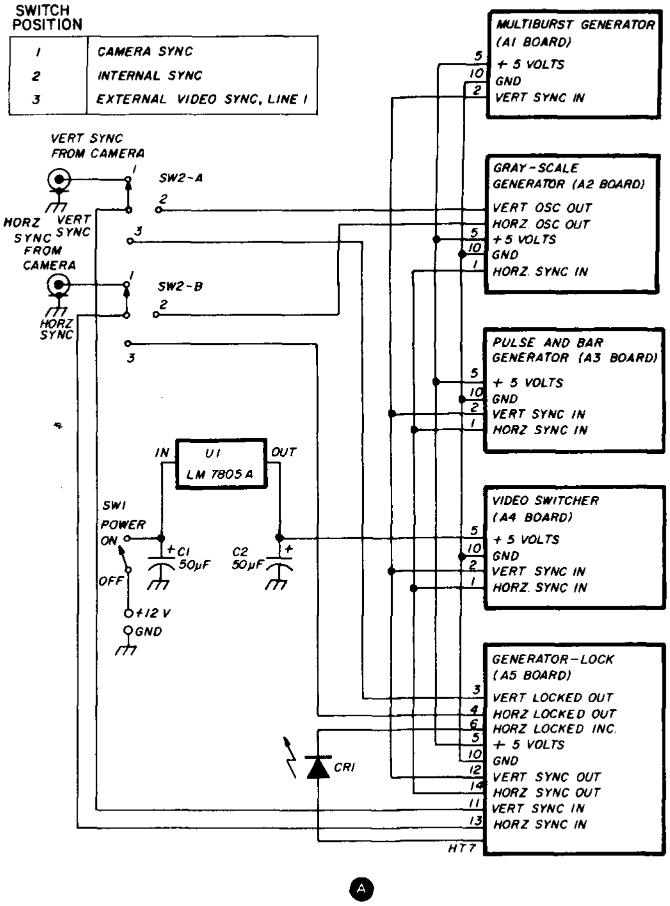
4. Adjust R5 for horizontal position of top part of pulse and bar.

5. Adjust R6 for horizontal position of top part of pulse and bar.

Video switcher (A4 board).

1. Adjust R23 for 1.5 volts p-p video at output of test point 6 when you have 1 volt at input.

2. Adjust R17 for 1 volt at test point 3. R1-R4 are front-panel controls but could be preset pots on board.



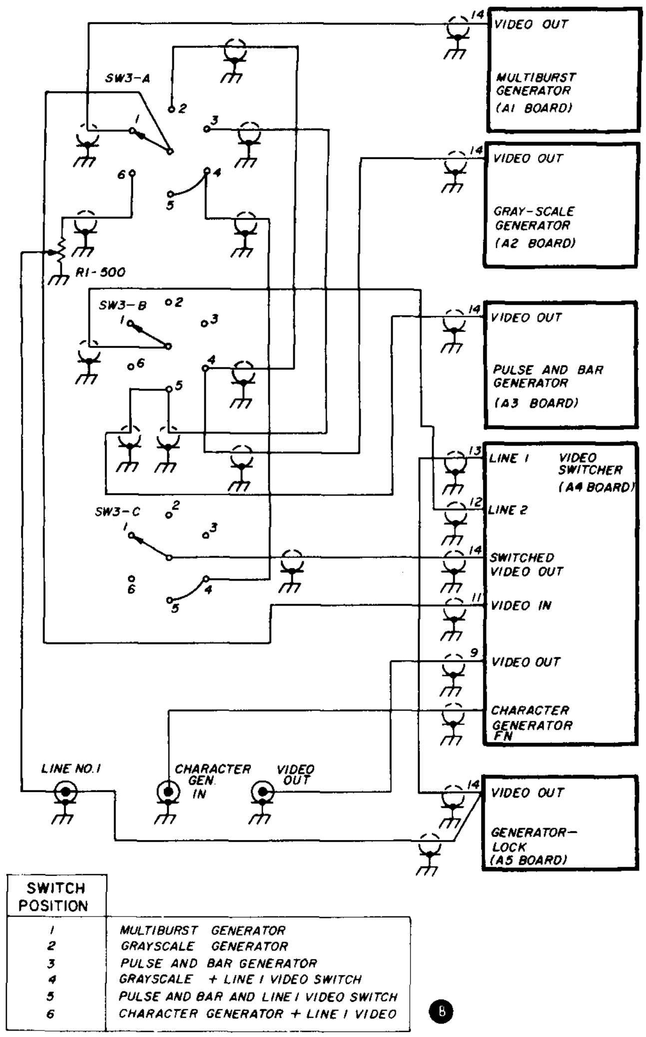
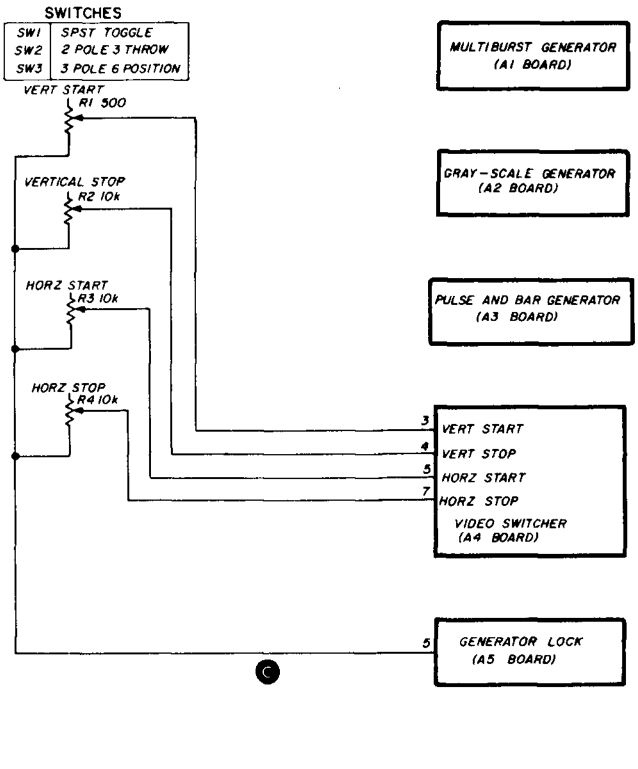


fig. 5. Circuit-board interconnections. (A) shows switching between horizontal and vertical sync signals from camera and the five PC boards. Function-generator switch logic is shown in (B). Interface between window-position controls and video switcher-Gen-Lock inputs is shown in (C).



Gen-Lock (A5 board).

1. Adjust R3 for clipping of video at test point 1.

2. Adjust R7 for 15,750 kHz at test point 4 with no video input at A5 pin 1.

This video console was constructed on five PC boards, one for each generator. It was done this way for ease of construction and system checkout. You can use any one of the generators or switches by itself. Just insert the vertical and horizontal sync signals and the +5 volts to the board you want to use. I've had very good results with this console and a lot of fun in its construction and use.

references

1. W. E. Parker, W8DMR, "A Multiburst Generator," *A5* magazine, September-October, 1973.
2. Al Lipkin, K3AEH, "Let's Build A Staircase To The Bars," *A5* magazine, May-June, 1977.
3. Gerald A. Eastman, *Television Systems Measurements*, Tektronix, Inc., September, 1969.

ham radio

More Details? CHECK—OFF Page 110

Yagi antenna design:

performance calculations

Development of a mathematical model of the Yagi antenna for computing antenna gain, front-to-back ratio, and operational bandwidth

Since its invention by H. Yagi and S. Uda of Tohoku University in 1926,[1] the Yagi-Uda antenna — commonly referred to as the *Yagi* — has received a great deal of theoretical and experimental attention. The Yagi has also become the most widely used Amateur Radio communications antenna, not only because of its excellent performance characteristics over the rather narrow frequency bands occupied by Amateurs, but also because of its remarkable tolerance to construction variations and even construction faults; it is an antenna that "wants to work."

Those readers who are interested in the theoretical basis of Yagi linear array antennas should take a look at the excellent book published in 1954 by S. Uda and Y. Mushiake;[2] this book is highly recommended and contains sixty-six relevant references. There are several other excellent reference works on the Yagi including those by Kraus,[3] King,[4] and Walkinshaw;[5] for those interested in the experimental side of Yagi arrays, attention is drawn to Ehrenspeck and Poehler,[6] Lindsay,[7] Greenblum,[8] and Viezbicke.[9] Reference 9, National Bureau of Standards *Technical Note 688*, describes the results of a decade-long NBS experimental investigation of Yagi antennas. Although this study represents one of the most complete and relevant sources of information on the Yagi, the report is flawed by inconsistencies, incomplete experimental information, and above all, measurement techniques which are sensitive to the effective height of ground midway between the transmitter and receiver. Nevertheless, the rich range of experimental results in NBS *Technical Note 688* provide an excellent area to test the validity of theoretical ideas.

It appears to me that designers of a high-performance Yagi array are faced with four facts:

1. Accurate antenna experiments are very difficult to make, especially if the antennas are designed to be used over earth. There are many variables, and it is difficult (if not impossible) to avoid unwanted reflections. Also, accurate instrumentation is simply not available for many of the quantities to be measured (current distribution in the parasitic elements, for example).

2. Conceptual design ideas are often misleading: *e.g.*, the concept of "optimum element spacing." Optimum, indeed, but with respect to what?

3. Practical design of real antenna components in some cases does not exist; a physically "tapered" element, for example, must be significantly longer than an equivalent cylindrical element, but by how much?

4. A good theoretical basis for design is uncertain. First of all, a real antenna must be simulated by a simplified physical model; the accuracy of the final result depends crucially on the excellence of this physical simulation or model. Secondly, the physical model, in conjunction with accepted physical laws and a modern computer, is used to compute the electrical performance of the Yagi model, *i.e.*, the parasitic element (parasite) currents first, and the spatial radiation pattern second. Since both computations involve simplifying approximations, overall accuracy depends directly on the excellence of physical modeling and the accuracy of the necessary mathematical approximations which are made.

I shall attempt to address each of these four items over the next several months. I have broken the subject down into six major categories, listed below, which will be covered in separate articles.

By James L. Lawson, W2PV, 2532 Troy Road, Schenectady, New York 12309

1. Modeling and computational methodology

2. Simple Yagis; free-space performance

3. Earth (ground) effects

4. Preferred designs

5. Scaling and construction corrections; specific designs

6. Stacking, screening, and scattering

I shall address the subject primarily in terms of antenna arrays which are most useful in the frequency range from 5 to 30 MHz, including designs ranging in size up to the largest practical levels. "Conventional" Yagi components will generally be used, but there will be some discussion of quads and of the quad-Yagi hybrid known as the *quagi*. For convenience, I will use horizontal polarization unless otherwise stated.

antenna properties

Before beginning an investigation of antenna characteristics it is necessary to define design criteria; what antenna properties are important and how can those properties be defined in quantitative terms? The antenna *user* is concerned with several properties:

1. Antenna gain G or directivity

2. Pattern (including front-to-back ratio, F/B)

3. Bandwidth

4. Feedline matching or standing-wave ratio

5. Cost

6. Longevity (wind survival, corrosion resistance, etc.)

Of these, the first four are *electrical* properties; the last two depend basically on construction engineering and will not be discussed further. Feed-line match (item 4) is controlled, at one frequency at least, by the matching system which transforms the antenna driving-point impedance to the transmission line's characteristic impedance. We are interested in the *inherent* driving point bandwidth of the antenna, specifically the actual driving-point impedance and its behavior with frequency.

Antenna gain, pattern, and bandwidth (items 1, 2, and 3) must be defined rather carefully. The gain (and directivity) is clearly of paramount importance; I shall use the definition of isotropic gain for all situations, *i.e.*, the ratio of *maximum* radiated energy flux density (at the "best" elevation angle) to the average radiated energy flux density (averaged over the 4π solid angle). This is equivalent to using an isotropic reference antenna in free space.

While the antenna's complete spatial pattern is of concern to the user, it is basically not practical to measure it or to specify it. The pattern characteristics of primary interest are the angular widths (horizontal and vertical) of the main beam and the amount of back radiation. The beam widths are rather accurately and simply determined by the antenna gain or directivity (see Kraus, page 25[3]).

Radiation in the rear hemisphere is usually variable and consists of one or more lobes. Perhaps the single most meaningful measure of rear radiation is the front-to-back ratio, or F/B, but we must define where the front wave is to be measured (elevation angle), where the back wave is measured, and what property of the waves is used to obtain the ratio. One popular concept is to plot the field strength, E, pattern of the antenna in free space and compute the ratio of front (maximum) field strength, E_F, to that found in the reverse (back) direction, E_R. The ratio can be also expressed in decibels as $(20 \log_{10} E_F/E_R)$.

What is the front-to-back ratio of a *real* antenna over earth or ground? I define this quantity as the ratio of maximum front power or energy flux density, W_F, (at an elevation angle where this maximum occurs) to the rear power or energy flux density, W_R, at the *same* rear elevation angle. This can also be expressed in decibels as $10 \log_{10} W_F/W_R$.

Note that this F/B ratio is only one parameter of the complete antenna pattern. It is perfectly possible, in principle, to have an antenna with a large F/B ratio defined in this way, but which has serious backward (but not directly back) lobes. Nevertheless, in the interest of simplicity I shall retain this simple notion of F/B ratio; it is perhaps the most important single index of pattern behavior.

The last parameter is the frequency bandwidth, but there are at least three important bandwidths: 1) the bandwidth of the driving-point impedance (electrical input), for example; 2) the bandwidth over which the gain remains high; and 3) the bandwidth over which the F/B ratio remains high. All three are important, so it's necessary to measure or calculate all three. This is best done by observing a quantitative frequency-swept plot of them all.

computation vs experiment

Antenna characteristics can be determined either by experimental measurements on a physical model or by calculations from a mathematical representation of the physical model. Which should be used? Experimental measurements are laborious and it is difficult to ensure accuracy. By contrast, computer calculations are fast and, in principle, can be made with great accuracy. Using a modern computer, a large number of antenna configurations can be investigated in a few days; a number it would take a life-time to explore experimentally! Moreover, because of the inherent accuracy of calculations, subtle changes and radiative coupling effects can be explored. Therefore, it appears that if a computational procedure is believable, it can be used *very* effectively. *Careful experimental tests are needed,* however, to validate the computation methods.

modeling

A real Yagi antenna can be represented physically by a set of parallel cylindrical conducting elements, each of which has space coordinates at its center of X, Y, and Z. As shown in **fig. 1**, the Yagi will be oriented so that the elements lie parallel to the Z axis and the boom is parallel to the X axis. In free space, the origin of this coordinate system can be placed anywhere, but when modeling a Yagi over the earth it will be advantageous to locate the origin on the conducting earth plane.

The elements themselves approximate a half-wave in length; the reflector, R, is usually somewhat longer than a half-wavelength, the drive element, DR, is normally about a half-wavelength, and the directors, $D1$ and $D2$ (or more), are somewhat shorter than a half-wavelength. For convenience, and to make the representation independent of wavelength, all coordinates, lengths, and dimensions will be expressed in wavelengths at some chosen design center frequency, f_o.

This model is clearly a simplification of a real Yagi. A real Yagi, for example, does not ordinarily have strictly cylindrical elements; real elements usually have telescoping diameters with connecting hardware clamps; moreover, the elements are mounted at their centers with plates or brackets to the boom, which is usually a conductor.

In this mathematical model I have totally neglected

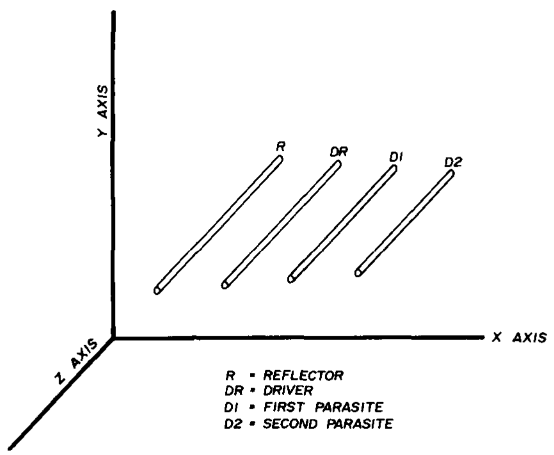


fig. 1. Basic model of the Yagi antenna showing the relationship of the elements, which are parallel with the Z axis; the boom is parallel to the X axis.

the conducting boom; this is justified only if the real Yagi is completely symmetric around the boom. Symmetry guarantees the electrical potential of each parasitic element at its center to be zero and guarantees no mutual coupling to the boom — hence no *current will flow along the boom,* and the boom can be neglected.

We also assume the driven element to be open at its center and driven from a balanced source; this eliminates current along the boom. The real Yagi driven element, if fed from a balanced source, will also induce no boom current. However, unbalanced feed systems can, in principle, produce currents along the boom which are not considered in the model. Unbalanced feed systems such as the gamma match are usually not especially troublesome in this respect, because if the driving point impedance of the element is relatively low, as it usually is, the voltage impressed on the boom is also low and boom current will be correspondingly low. Moreover, the loaded Q of the driven element is usually high enough to insure reasonable symmetry of element currents; this also makes for low induced boom currents. Incidentally, it is possible to construct the real Yagi with insulating element-to-boom supports; this helps to ensure negligible boom currents.

The clamping and mounting hardware used in a practical Yagi all amount to corrections in the *actual length* of the element to an *equivalent length.* Similarly, the telescoping (radius tapering) element will act like a cylindrical element of the same *average* radius, but with a different *equivalent* length! The way in which the actual element dimensions can be converted to a cylindrical element of the same average radius and equivalent length will be discussed later, as will corrections to length caused by mounting hardware. For the moment, note that the real Yagi element dimensions can be converted to equivalent cylinder dimensions for use in the model. As a side note, the element radius taper corrections to convert actual lengths to equivalent cylinder lengths are substantial; this is often overlooked by builders who try to use someone else's element lengths with different element diameters on tapering.

In the mathematical model you can arrange any number of parasitic elements and any number of drivers. It will be shown later how to use the model to approximate a quad or a quagi, or even a "broadband" drive (as in the KLM antennas) where there is a main driver but one or more dependent drivers which are connected through a transmission line to the main driver.

computational methodology

With this mathematical model we are in a position to compute the performance of the Yagi array — to table 1. Element reactance for different length-to-diameter ratios, K. $X_{0.50}$ is the reactance of an element 0.5λ long; $X_{0.45}$ denotes the reactance of an element 0.45λ long; ΔX is the reactance change when shortening the element from 0.5 to 0.45 wavelength. As shown in fig. 2, a plot of ΔX vs K falls on a straight line defined closely by eq. 1.

K	$X_{0.50}$	$X_{0.45}$	ΔX	eq. 1
10	34.1799	21.6094	− 12.5705	− 11.030
30	36.7352	4.6906	− 31.0446	− 31.561
50	37.4666	− 3.8791	− 41.3457	− 41.107
100	38.2110	− 15.8869	− 54.0979	− 54.060
200	38.7673	− 28.1857	− 66.9530	− 67.013
10^3	39.6375	− 57.3954	− 97.0329	− 97.090
10^4	40.3603	− 99.9997	− 140.3600	− 140.120
10^5	40.7961	− 143.0558	− 183.8519	− 183.150
10^6	41.0873	− 186.3402	− 227.4275	− 226.180

find out how the performance of the array varies with frequency f around the design f_o. The first task is to compute the complex currents (or current magnitudes and phases) which flow in all elements as a result of driver excitation; to do this, it is necessary to determine both the self and mutual impedances of all elements.

I shall start with the behavior of a single nearly half-wavelength element in free space. The self impedance of such an element has been calculated by many authors; an excellent comparison of the various methods is given by Kraus[3] (pages 272-276). Uda and Mushiake have used the method originated by Hallen (boundary-value problem) and presented an approximate equation and a table (pages 23-24) which show the self impedance of a cylindrical nearly half-wavelength doublet as functions of radius and length. It is apparent from this table that a half-wavelength doublet has an impedance of about 73 + j40 ohms, so a somewhat shortened antenna is needed to resonate (to show zero reactance). The required

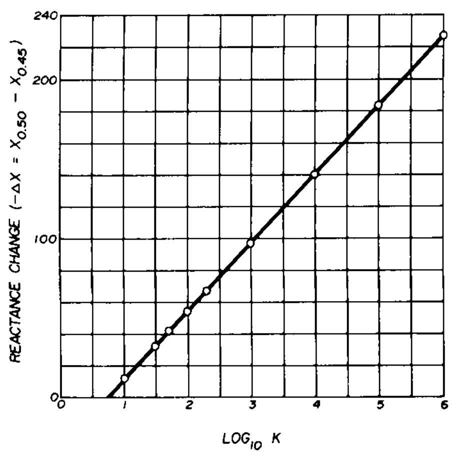


fig. 2. Graph showing the relationship between the length-to-diameter ratio, K, of a half-wavelength element and the reactance change, ΔX, as element length is reduced to 0.45λ from 0.5λ.

shortening is basically only a function of K, which is defined as the ratio of (central) wavelength to element radius. In **table 1**, I have extended Uda and Mushiake's data to a wider range of K values and have calculated the reactance $X_{0.50}$ (in ohms) of the full half-wave dipole and $X_{0.45}$ of an element 0.45 wavelength long; ΔX is the reactance *change* in ohms when shortening the element from 0.5 to 0.45 wavelength.

If you plot ΔX against $\log_{10} K$, you will find, remarkably, that the points fall in a straight line (**fig. 2**). This suggests that the reactance change ΔX can be expressed with rather good accuracy as:

$$\Delta X = -43.03 \log_{10} K + 32 \tag{1}$$

The accuracy of this empirical relationship is remarkable over the range of K of real interest $(100 < K < 10{,}000)$.

Note that a simple series-resonant circuit displays an input reactance of:

$$X = 2RQ(F/FR - 1) \tag{2}$$

where Q is the electrical Q factor ($Q = 2\pi f_o L/R$)

F is the frequency relative to f_o

FR is the resonant frequency of the circuit relative to f_o

R is the series resistance

Equations 1 and **2** can be used to derive:

$$RQ = (215.15 \log_{10} K - 160) \tag{3}$$

In other words, the dipole element behaves electrically like a series-resonant circuit of resistance R and Q given by the empirical relationship of **eq. 3**.

You may also use **eq. 1** to derive the resonant length (zero reactance), LER, of the dipole element in units of wavelength:

$$LER = [1 - (10.7575 \log_{10} K - 8.00)^{-1}] \tag{4}$$

It is interesting to note that the ratio of the resonant length to a true half-wavelength depends only on K! Some representative values computed from **eq. 4** are shown in **table 2** and graphically illustrated in **fig. 3**.

table 2. Element resonant length $2 \cdot LER$ (in units of $\lambda/2$) for different length-to-diameter ratios K. These data are plotted in fig. 3.

K	2•LER	K	2•LER
30	0.8733	10^3	0.9588
50	0.9027	10^4	0.9715
100	0.9260	10^5	0.9782
200	0.9403	10^6	0.9823

Note that greater shortening is needed for thick cylinders than for thin wires, but even for very thin wires appreciable shortening is required to achieve resonance. Thus, if the actual length of an element is LE in terms of wavelengths at central design frequency f_o, and its resonant length is LER, its resonant frequency, FR (in terms of f_o), may be written as:

$$FR = LER/LE \tag{5}$$

The self impedance of such an element is then:

$$R + jX = 73 + j\,(430.30 \log_{10} K - 320)\,(F/FR - 1)\ ohms \tag{6}$$

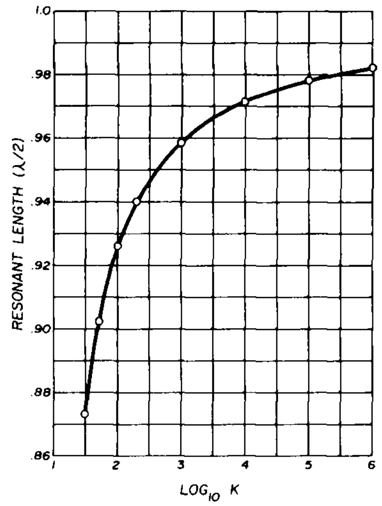


fig. 3. Resonant length of a half-wavelength element as a function of length-to-diameter ratio, *K*. Note that greater shortening is needed for thick elements (low *K*) but even very thin wires require appreciable shortening to achieve resonance.

The accuracy of this expression should be good to a very few per cent for elements within a few per cent of a half-wavelength long.

mutual impedance

Now must be considered the mutual impedance between two nearly half-wavelength elements separated by a distance s measured in wavelength λ. Good calculations have been made by several authors of both the real and imaginary components of this complex quantity, but only for the limiting case of infinitely thin, half-wavelength elements; equations, plots, and tables are shown in Kraus[3] (pages 265-268) and Uda-Mushiake[2] (pages 69-70). Kraus (page 266) also shows calculations by Tai for two cases of thicker, half-wavelength dipole elements. Tai's calculations suggest that inaccuracies caused by using the limiting thin case will not be large; therefore, for convenience, I use it for all calculations. I have extended the table of Uda-Mushiake, and in **table 3** show values in ohms for the real part of the mutual impedance ($RMUT$) and for the imaginary part ($XMUT$), as a function of element separation, s, in wavelength. For separations greater than $s = 1.5$, a reasonable approximation can be derived from:

$$RMUT = \frac{19.06}{s} \sin(2\pi s)\ for\ s > 1.5 \tag{7}$$

$$XMUT = \frac{19.06}{s} \cos(2\pi s)\ for\ s > 1.5 \tag{8}$$

Although some caveats are necessary, you now have the necessary tools to calculate the parasitic element currents. Recall that the physical model of the Yagi is a good representation only to the extent that proper corrections can be made for element hardware variances (clamping and mounting hardware and element radius taper). These corrections will be detailed later. Also recall that the computation of self and mutual impedances (**eqs. 4, 5, 6, 7, 8,** and **table 3**) are approximations! Though they are probably good approximations, and should give reasonably accurate results, you should not rely on them for accuracy better than a few per cent.*

computations

The first step is to calculate the complex currents (or magnitudes and phases) of all parasitic elements given the currents or voltages applied to all drivers. The method is uncomplicated, following the technique of P.S. Carter shown in Kraus,[3] (page 302). For simplicity, I will illustrate how this is done using one driver and three parasitic elements; extension to any number of elements will be obvious. For each element add all voltages and equate to the terminal voltage V_n:

$$\begin{aligned}
I_1Z_{11} + I_2Z_{12} + I_3Z_{13} + I_4Z_{14} &= V_1 \\
I_1Z_{21} + I_2Z_{22} + I_3Z_{23} + I_4Z_{24} &= V_2 \\
I_1Z_{31} + I_2Z_{32} + I_3Z_{33} + I_4Z_{34} &= V_3 \\
I_1Z_{41} + I_2Z_{42} + I_3Z_{43} + I_4Z_{44} &= V_4
\end{aligned} \tag{9A}$$

*Any improvement in these approximations will require a great amount of theoretical work through a rigorous examination of the boundary value problem with attention to:

1. Current distributions along driven and parasitic elements (they are somewhat different in principle).
2. Complete numerical solutions to both real and imaginary components of element self and mutual impedance; it will be necessary to distinguish mutual coupling coefficients between elements of different function, *i.e.*, driven to driven, driven to parasite, and parasite to parasite. In principle, all coefficients will depend on each affected element length and radius.

Assume in this example that the first three elements are parasites, *i.e.*, $V_1 = V_2 = V_3 = 0$ and that the fourth element is driven with the complex voltage V_4; Z_{nn} is recognized as the complex self impedance of the nth element, and Z_{jk} (which is the same as Z_{kj}) is the mutual impedance between the jth and kth element. Thus, all of these impedances can be calculated once the positions (and hence separations) of the elements are specified. Since there are four linear equations with four unknowns, I_1, I_2, I_3, and I_4, the easiest way to solve this array is by a matrix inversion. In matrix notation **eq. 9A** is represented by:

table 3. Complex mutual impedance as a function of element spacing, s (wavelength). The real part is designated R_{MUT} and the imaginary part as X_{MUT} (both in ohms).

s(λ)	R_{MUT}	X_{MUT}	s(λ)	R_{MUT}	X_{MUT}
0.	73.13	42.54	0.80	−18.49	12.26
0.05	71.66	24.27	0.85	−13.32	16.29
0.10	67.33	7.54	0.90	−7.49	18.55
0.15	60.43	−7.10	0.95	−1.55	18.99
0.20	51.40	−19.17	1.00	4.01	17.74
0.25	40.79	−28.35	1.05	8.75	15.04
0.30	29.26	−34.44	1.10	12.32	11.22
0.35	17.50	−37.42	1.15	14.52	6.71
0.40	6.22	−37.43	1.20	15.25	1.94
0.45	−3.97	−34.78	1.25	14.56	−2.66
0.50	−12.53	−29.93	1.30	12.59	−6.70
0.55	−19.06	−23.42	1.35	9.62	−9.84
0.60	−23.31	−15.87	1.40	5.97	−11.88
0.65	−25.21	−7.94	1.45	2.01	−12.70
0.70	−24.86	−0.25	1.50	−1.89	−12.30
0.75	−22.50	6.63			

$$\begin{vmatrix} Z_{11} & Z_{12} & Z_{13} & Z_{14} \\ Z_{21} & Z_{22} & Z_{23} & Z_{24} \\ Z_{31} & Z_{32} & Z_{33} & Z_{34} \\ Z_{41} & Z_{42} & Z_{43} & Z_{44} \end{vmatrix} \times \begin{vmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{vmatrix} = \begin{vmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{vmatrix} \quad \textbf{(9B)}$$

or: Z (matrix) $\times$ I (vector) $=$ V (vector) where all terms are complex.

The solution is I (vector) $= Z^{-1}$ (inverted matrix) $\times$ V (vector) where $Z \times Z^{-1} = 1$.

The process of matrix inversion is readily accomplished with a computer using matrices having complex terms, *e.g.*, with a program usually called CLINEQ under FORTRAN IV. Although the actual solution is usually done through a mathematical process known as Gaussian elimination, the result is equivalent to matrix inversion. With this technique, a computer will provide solutions quickly for very large arrays of fifty elements or more.

If you wish to specify the driven element *current*, I_4, instead of voltage, V_4, rewrite the first three parasitic equations (**eq. 9**) as:

$$\begin{aligned} I_1Z_{11}+I_2Z_{12}+I_3Z_{13} &= -I_4Z_{14} \\ I_1Z_{21}+I_2Z_{22}+I_3Z_{23} &= -I_4Z_{24} \\ I_1Z_{31}+I_2Z_{32}+I_3Z_{33} &= -I_4Z_{34} \end{aligned} \quad \textbf{(10)}$$

This (smaller) array can be solved in the same way for I_1, I_2, and I_3 and the results used in the fourth equation:

$$I_1Z_{41}+I_2Z_{42}+I_3Z_{43}+I_4Z_{44} = V_4 \quad \textbf{(11)}$$

to solve for V_4. The driving point impedance for either calculation is simply:

$$Z_4 = V_4/I_4 \quad \textbf{(12)}$$

This procedure is best done on a computer, and it is not difficult to write a suitable program. Although I have written a number of such programs in FORTRAN IV, I would prefer not to supply them. It has been my experience that those who understand programming can easily write their own; those who are not capable of programming invariably need substantial assistance, which I am unwilling to supply.

summary

In this article I have discussed the basic properties of the Yagi antenna, and the construction of a mathematical model which can be used for computer analysis. In the next article of this series I will outline the computer programs which accomplish this analysis, and will confirm, using published experimental information, that calculated Yagi performance is in close agreement with that realized in practice.

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ham radio

remote synthesized fm transceiver for 2 meters

Construction details for a remote synthesized 2-meter transceiver with 220-MHz control

Activity on the Amateur 220-MHz band has always been on the sparse side, although in recent years more and more fm operators in the urban areas have been moving up to 220 to avoid the congestion of 2 meters. For a number of years we were seriously threatened with the loss of 220-MHz to the CB interests, but that threat seems to have passed for the moment; other services still covet the 220-MHz allocation, however, and one of the best ways to protect the band is to increase the activity level.

With a band as good as 220 MHz, I used to wonder why it was not being used to its fullest; I concluded that few Amateurs really "know" about 220, so there is little demand for good equipment, and, consequently, there is a limited selection. Just by way of introduction, the 220-MHz band has a number of characteristics to recommend it: it provides propagation similar to that of 144 MHz, but the noise levels are considerably lower; 220 is wider than 2 meters by 1 MHz, and 220-MHz antennas require less space for the same amount of gain.

After I had sold myself on the advantages of 220-MHz, I decided to see what I could do to generate more interest in the Atlanta area. I first put up a 220-MHz repeater; no one, however, seemed very interested. I had considered adding an autopatch when I got an idea for a remote base. Not just a fixed or few selectable channel remote base, but one which was fully synthesized and could be user programmed to any frequency in the 2-meter band.

features and limitations

I decided to make use of the excellent transmitter, receiver, and synthesizer kits manufactured by VHF Engineering and to develop only the necessary control circuits to operate the synthesizer and associated circuits. I felt it should be possible to operate any frequency combination between 144.105 and 147.995 MHz; it would be necessary to dial up the receive freqency prior to the transmit frequency so a listening watch could be made prior to transmitting (later it would be possible to dial up receive frequencies without transmit frequencies so the band can be scanned manually if desired).

theory of operation

Fig. 1 is a functional diagram of the overall system starting with a basic 220-MHz repeater. The audio from the repeater receiver is connected to a tone-pad decoder which feeds a BCD data bus; this bus carries data from the operator to three circuit boards.

The first, the access and control board senses the

By Neil Stone, WB4UPC, Postbox 7054, Marietta, Georgia 30065

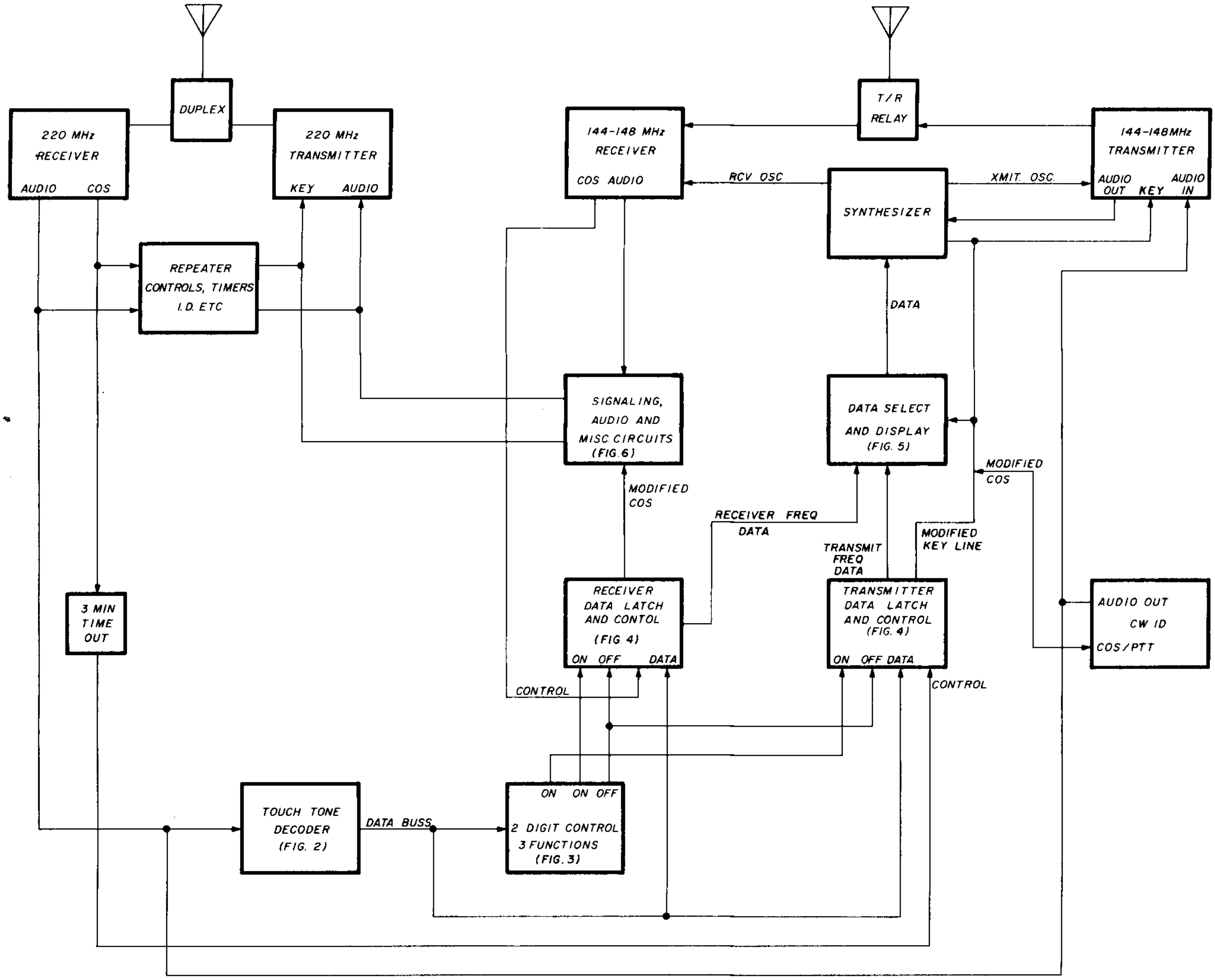


fig. 1. Block diagram of the basic remote system. A 220-MHz transceiver provides the control for the synthesized 2-meter transceiver. Circuit boards and parts kits are available from Creative Electronics, Box 7054, Marietta, Georgia 30605.

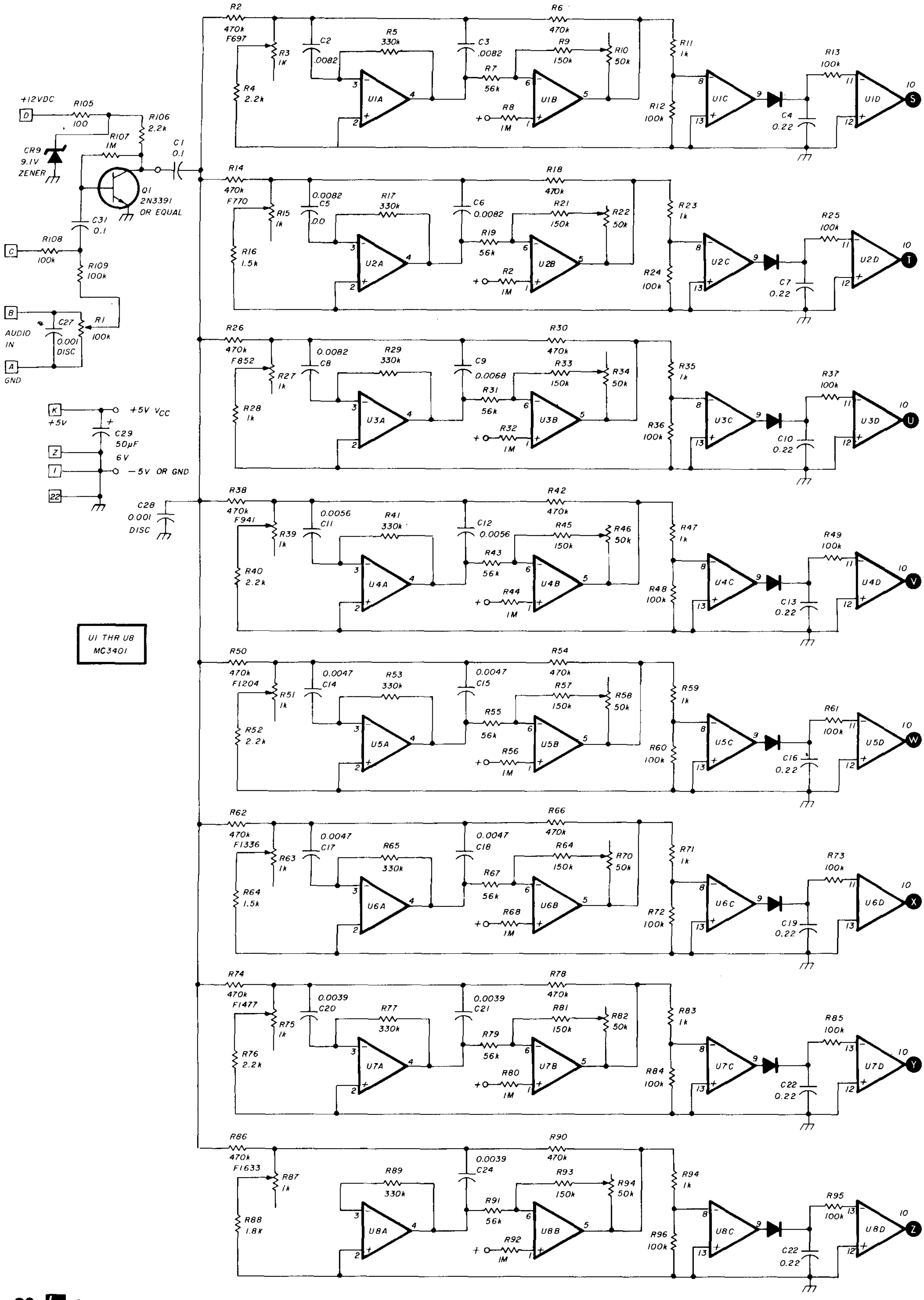
first two digits, which alert either of the other two boards (both identical) to accept the information following on the data bus. The access and control board will also sense two digits which signal the remote base to shut down. The two data latch boards, when enabled by the access and control board, store the subsequent four digits as frequency information. This board also senses whether or not a valid (in band) frequency has been received.

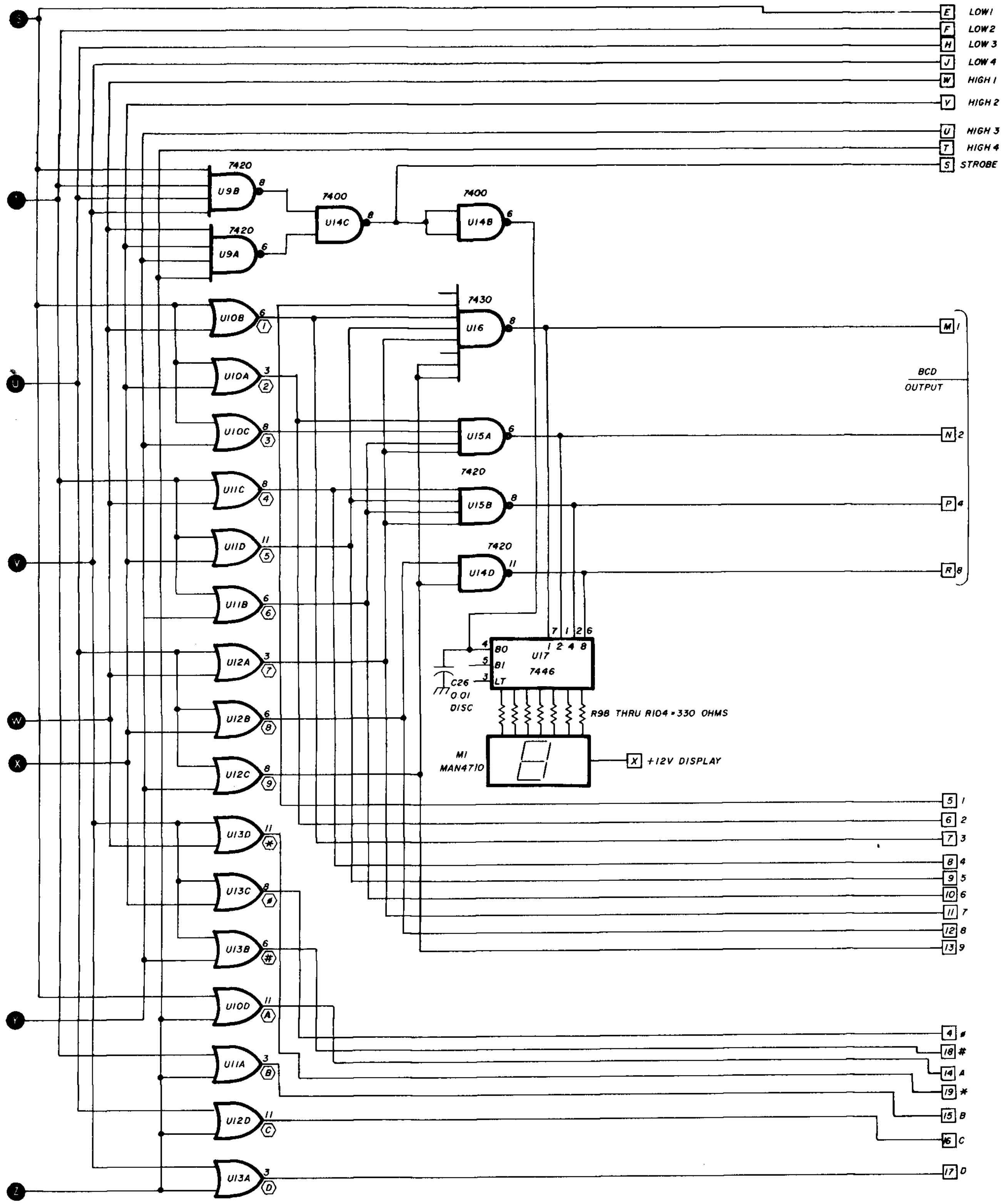
The data outputs from these two boards are connected to the data select and display board. This board contains the necessary circuitry to select whether the receiver or transmit data latch board will control the synthesizer frequency; it also displays the desired frequency and retains the last transmit frequency for the final identification. The data output from this board is connected to the synthesizer, which controls the receiver and transmitter. The audio and COS lines from both the repeater and remote base are processed on the miscellaneous circuits board.

tone-pad decoder

The tone-pad decoder (**fig. 2**) consists of eight active filters, U1 through U8, each of which is tuned to a standard *Touch-Tone** frequency. Except for the frequency-determining components, the following description of the 697-Hz filter is applicable to all others: Audio from the repeater receiver is coupled into the detector through a level adjust control, R1. The input on pin C allows the tones from a local pad to be applied to the decoder. The output from the active filter, U1A and U1B, is coupled through R11 to reduce the loading effects of U1C on the active filter. U1C normally is in a conducting state (output near

**Touch-Tone* is a registered trademark of the American Telephone and Telegraph Company.


+12VDC
D
R105 100
R106 2.2k
CR9 9.1V ZENER
R107 1M
Q1 2N3391 OR EQUAL
C1 0.1
C31 0.1
C
R108 100k
R109 100k
B
AUDIO IN
C27 0.001 DISC
R1 100k
A
GND
K
+5V
+5V VCC
C29 50µF 6V
Z
1
22
−5V OR GND
C28 0.001 DISC
U1 THR U8 MC3401
R2 470k F697
R3 1K
R4 2.2k
C2 .0082
R5 330k
C3 .0082
R6 470k
R7 56k
R8 1M
R9 150k
R10 50k
U1A
U1B
R11 1k
R12 100k
U1C
C4 0.22
R13 100k
U1D
S
R14 470k F770
R15 1k
R16 1.5k
C5 0.0082
R17 330k
C6 0.0082
R18 470k
R19 56k
R2 1M
R21 150k
R22 50k
U2A
U2B
R23 1k
R24 100k
U2C
C7 0.22
R25 100k
U2D
T
R26 470k F852
R27 1k
R28 1k
C8 0.0082
R29 330k
C9 0.0068
R30 470k
R31 56k
R32 1M
R33 150k
R34 50k
U3A
U3B
R35 1k
R36 100k
U3C
C10 0.22
R37 100k
U3D
U
R38 470k F941
R39 1k
R40 2.2k
C11 0.0056
R41 330k
C12 0.0056
R42 470k
R43 56k
R44 1M
R45 150k
R46 50k
U4A
U4B
R47 1k
R48 100k
U4C
C13 0.22
R49 100k
U4D
V
R50 470k F1204
R51 1k
R52 2.2k
C14 0.0047
R53 330k
C15 0.0047
R54 470k
R55 56k
R56 1M
R57 150k
R58 50k
U5A
U5B
R59 1k
R60 100k
U5C
C16 0.22
R61 100k
U5D
W
R62 470k F1336
R63 1k
R64 1.5k
C17 0.0047
R65 330k
C18 0.0047
R66 470k
R67 56k
R68 1M
R64 150k
R70 50k
U6A
U6B
R71 1k
R72 100k
U6C
C19 0.22
R73 100k
U6D
X
R74 470k F1477
R75 1k
R76 2.2k
C20 0.0039
R77 330k
C21 0.0039
R78 470k
R79 56k
R80 1M
R81 150k
R82 50k
U7A
U7B
R83 1k
R84 100k
U7C
C22 0.22
R85 100k
U7D
Y
R86 470k F1633
R87 1k
R88 1.8k
R89 330k
C24 0.0039
R90 470k
R91 56k
R92 1M
R93 150k
R94 50k
U8A
U8B
R94 1k
R96 100k
U8C
C22 0.22
R95 100k
U8D
Z



groups	desired frequency	tone pad frequency table frequency adjustment	Q adjust	groups	desired frequency	tone pad frequency table frequency adjustment	Q adjust
Low 1	697 Hz	R3	R10	High 1	1209 Hz	R51	R58
Low 2	770 Hz	R15	R22	High 2	1336 Hz	R63	R70
Low 3	852 Hz	R27	R34	High 3	1477 Hz	R75	R82
Low 4	941 Hz	R39	R46	High 4	1633 Hz	R87	R94

fig. 2. Schematic of the tone decoders. All resistors are 1/4 watt, 5 per cent; all capacitors are Mylar unless otherwise specified.

zero volt). When a signal appears on its input; however, the negative-going peaks cause the output to go positive. This positive voltage is coupled through CR1 across C4, resulting in a fast attack. U1D operates as an open gain amplifier; the output is zero for a valid tone group.

The outputs from the four low-group tones are each connected to OR gates U10 through U13. The other gate input is connected to the appropriate output of the high-group filter detector. The outputs of each OR gate provide a zero logic state for the digit being received. These outputs are then connected to a series of logic gates, U14D, U15D, and U16D, which convert them to a BCD format. Included in this output format is a negative-going strobe, generated by U9 and U14C, which signals the other circuits that the data is valid.

In addition to the BCD data and strobe, other outputs are provided for each individual tone group, digits including # and *, and the extra right hand column, A, B, C, and D. These outputs all go to a low state when valid and may be used, if desired, for control functions.

access and control board

The access and control board, **fig. 3**, accepts the information from the data bus or from the extra outputs of the tone-pad decoder and converts this data to the necessary system control signals. When the strobe goes low, it starts a timer, U7, which is connected to the other input of U9D. When the timer's output returns to a low state, and if a valid digit is still present, the output of U9D will go to high. This reduces the effects of voicing.

When U5 goes to zero, it triggers timers U8A and U8B. If a valid digit is recognized, as represented by zero output at U5, timing capacitor C20 discharges. When the strobe returns high, the capacitor starts to recharge. If another digit is received, the strobe again discharges C20. So long as a steady stream of digits is received by the tone pad decoder, the timer will not reset, allowing U10 to count the U8B output. When the digit stream ceases, U10 is reset to zero.

U8B act as a one shot, providing a pulse for each digit received from the tone-pad decoder. The single-shot pulse is coupled through gate U6D, divided by 10 through U10, and then applied to decimal decoder U11. The decoded BCD digit information, plus the U11 output form a programming matrix. When more than nine digits are received, an output from U11 stops the counter by inhibiting gate U6D; this prevents the counter from recycling.

On the other side of the matrix are three sets of circuits, all the same, each used for one of the control functions. Following is a description of the receiver access portion; the transmitter access portion and the disable portion are identical except that only the first and second digits can be used on the disable circuit. One U1B input, for the first digit to be recognized, is connected to the U11 matrix outputs. The other input is connected through the matrix to the desired, preset digit. Therefore, when a received digit corresponds to the desired sequence, U1B output goes low and is inverted by U5C. When the digit is released, the negative-going transition starts timer U3B, providing a window through NAND gate U6B when the second control digit must be received and recognized. If this occurs, the U6B output goes to a zero, sending a control signal to enable the receive mode data latch and control board. The other control functions enable the transmitter data latch and control board or can disable both boards.

data latch and control boards

Two data latch and control boards, **fig. 4**, are required: one for the receive frequency and one for transmit. When the access and control board signals receipt of the proper access code, it provides a zero-going pulse to the alert line (pin C) on the data latch board. This zero-going pulse performs several functions: It toggles U3A (which enables the counter U4, OR gate U12D, and NAND gate U13C), and U3B (which disables either the transmitter or receiver through OR gates U12B and U12C); it also provides a start pulse to U2B through U13D and U13C. When enabled, U4 counts the number of zero-going pulses on the strobe line.

The strobe pulses are conditioned by U2A to provide a single, short positive pulse regardless of how long the digit is held. These output pulses are also used to enable data latch chips before advancing the counter; this protects the currently stored digit and prepares for the next. The pulses from U2A are inverted by U16F and applied to one input of NOR gates U6A, U6B, U6C, and U6D.

The other gate input comes from BCD-to-decimal decoder U5. When more than five pulses have been counted by U4 and U5, a signal from U5 inhibits U1B, preventing the data latches from accidentally being recycled. As the counter advances from the starting point through three, each of the U6 NOR gates is allowed to pass the pulse generated by U2A; the following latches are sequenced to sample and store the information from the data bus.

In addition to decoding the data bus, the latch outputs are connected to a series of BCD-to-decimal decoders for sensing dialing errors, and/or the selection of out-of-band frequencies. The outputs of U17, U18, U19, and U20 are connected to a series of gates that check for specific frequencies. The U22C output goes low when out-of-band operation is sensed, sending a pulse through U15A, U15B, and U15C to

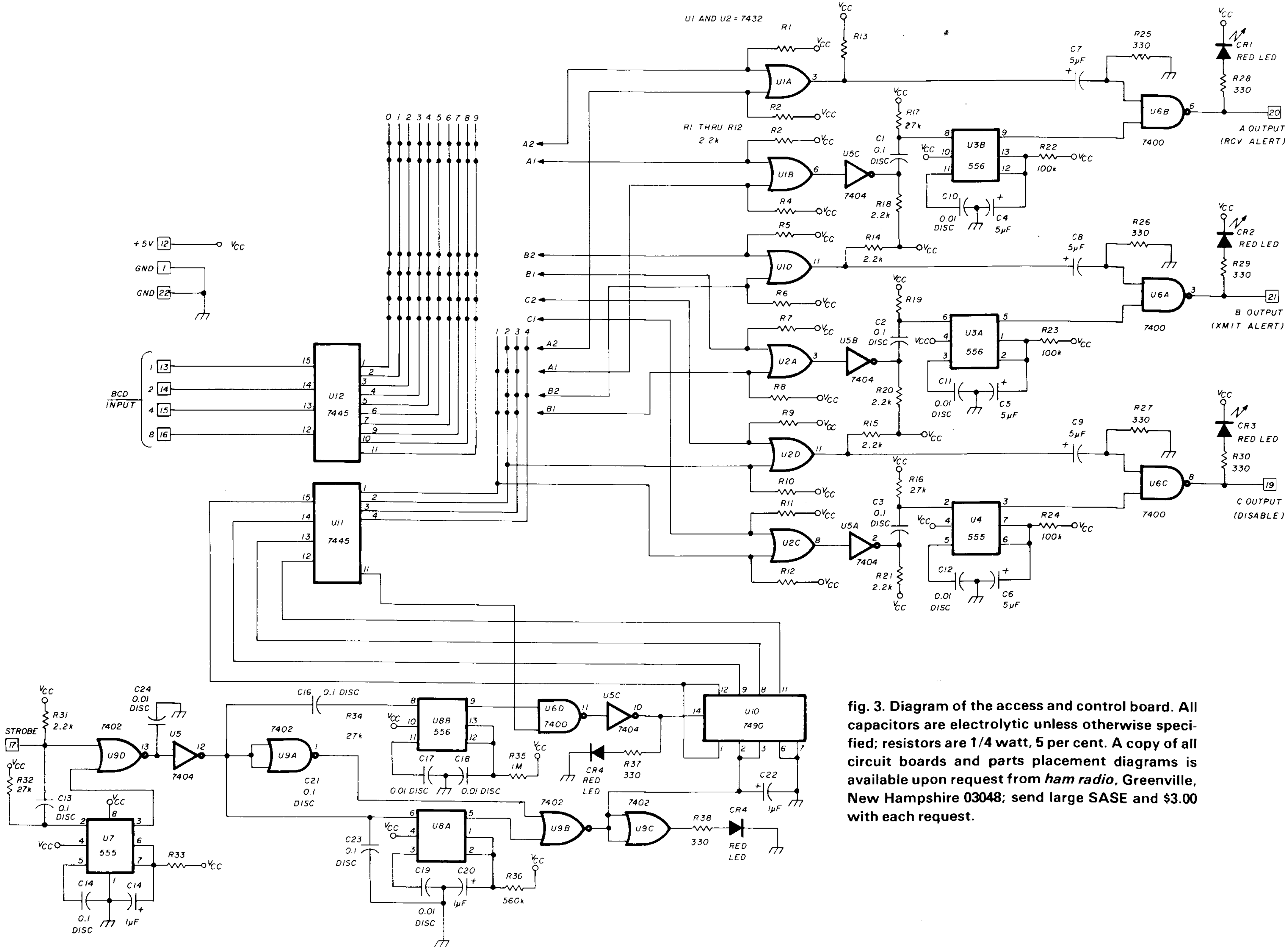


fig. 3. Diagram of the access and control board. All capacitors are electrolytic unless otherwise specified; resistors are 1/4 watt, 5 per cent. A copy of all circuit boards and parts placement diagrams is available upon request from *ham radio*, Greenville, New Hampshire 03048; send large SASE and $3.00 with each request.

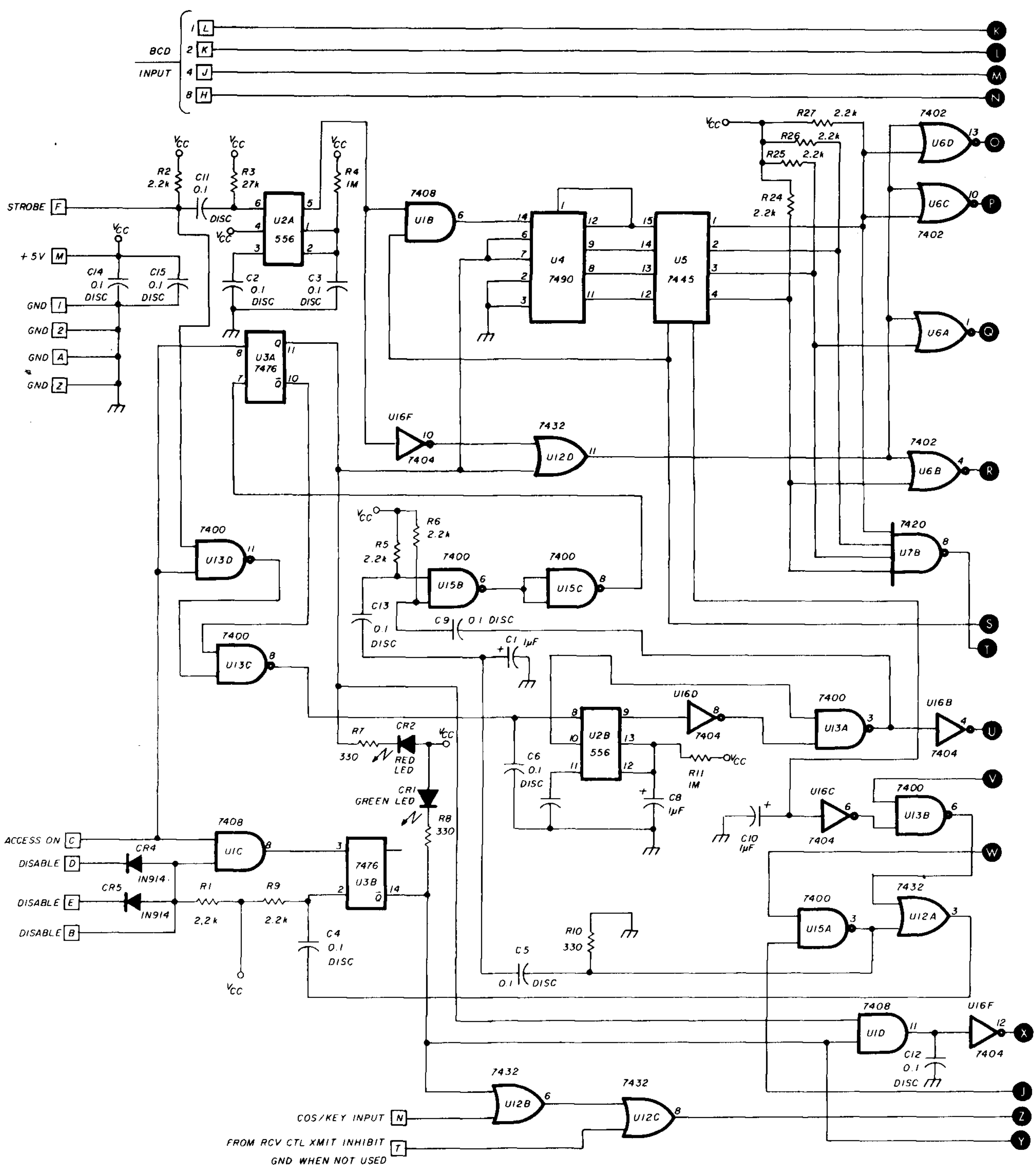
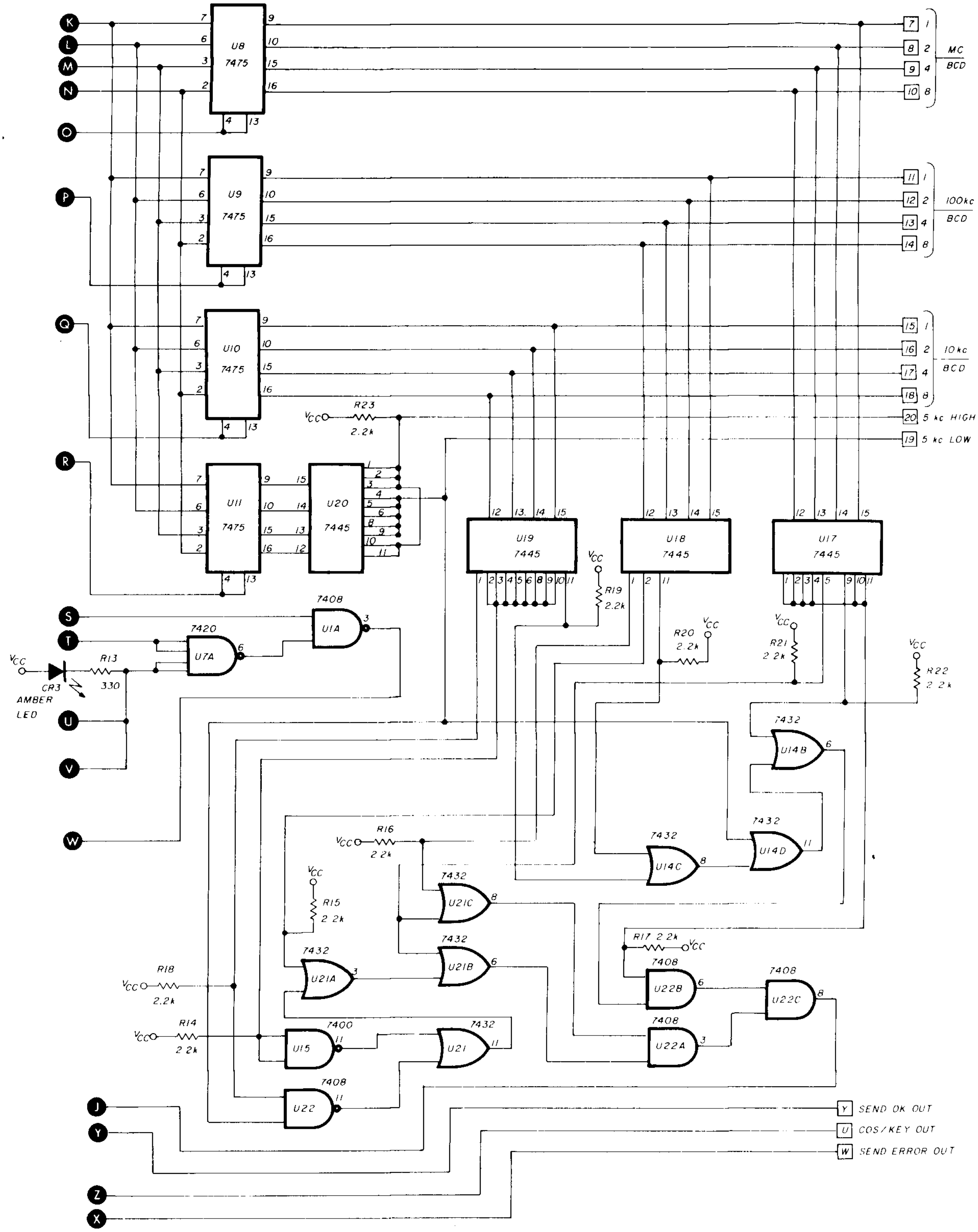


fig. 4. Circuit for the data latch and control board. All resistors and capacitors are as specified in fig. 3.

reset U3A. U12A blocks the reset pulse during the dialing time.

When the user has finished dialing, U2B is allowed to reset; both U13A inputs go high, passing a pulse through C9. This pulse is subsequently inverted by U15C and used to reset U3A and counter U4. U13A output is also connected to inverter U16B, which enables the circuits for testing number of digits dialed. If the tests are passed, U12A resets U3B, enabling U12B to pass the COR/COS input on pin N of the card edge connector.

If the wrong number of digits is received or an out-of-band signal is sensed, the reset signal is blocked by U12A, and U3A is reset by the output from U15A; U3B is not reset, leaving either the transmitter and/or the receiver disabled.



The main function of the data select and display board, **fig. 5**, is to determine whether the receiver or transmitter data latch and control board controls the synthesizer frequency. It also displays the operating frequency and the mode (receive or transmit). This board also senses when the transmitter is moved to a new frequency and instructs the identifier to send an ID; the old frequency is stored until the ID has been sent and then released.

The data select function is performed by U14, U15, and U16. The outputs are connected to three data latches (U11, U12, and U13) which normally have

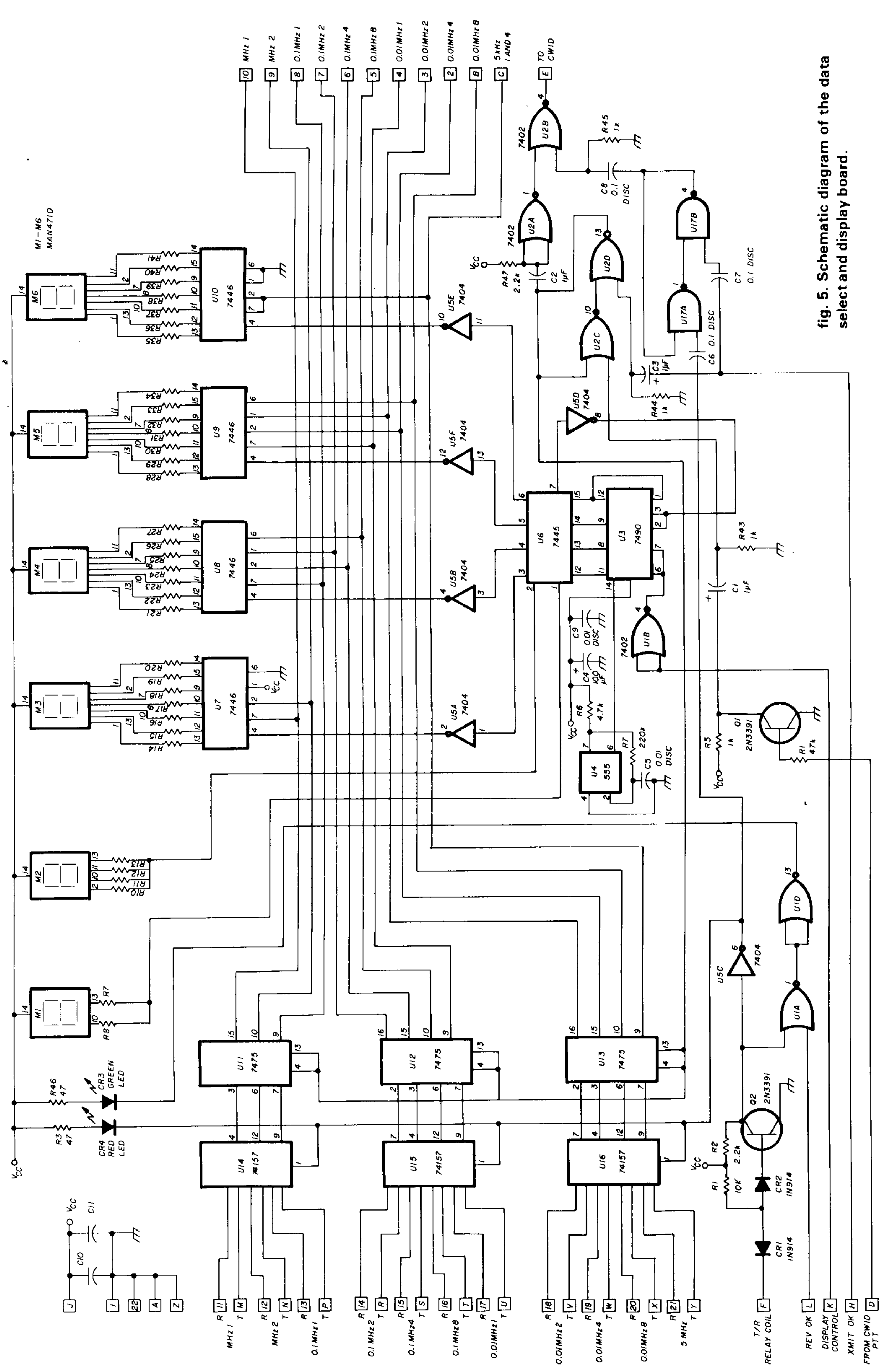


fig. 5. Schematic diagram of the data select and display board.

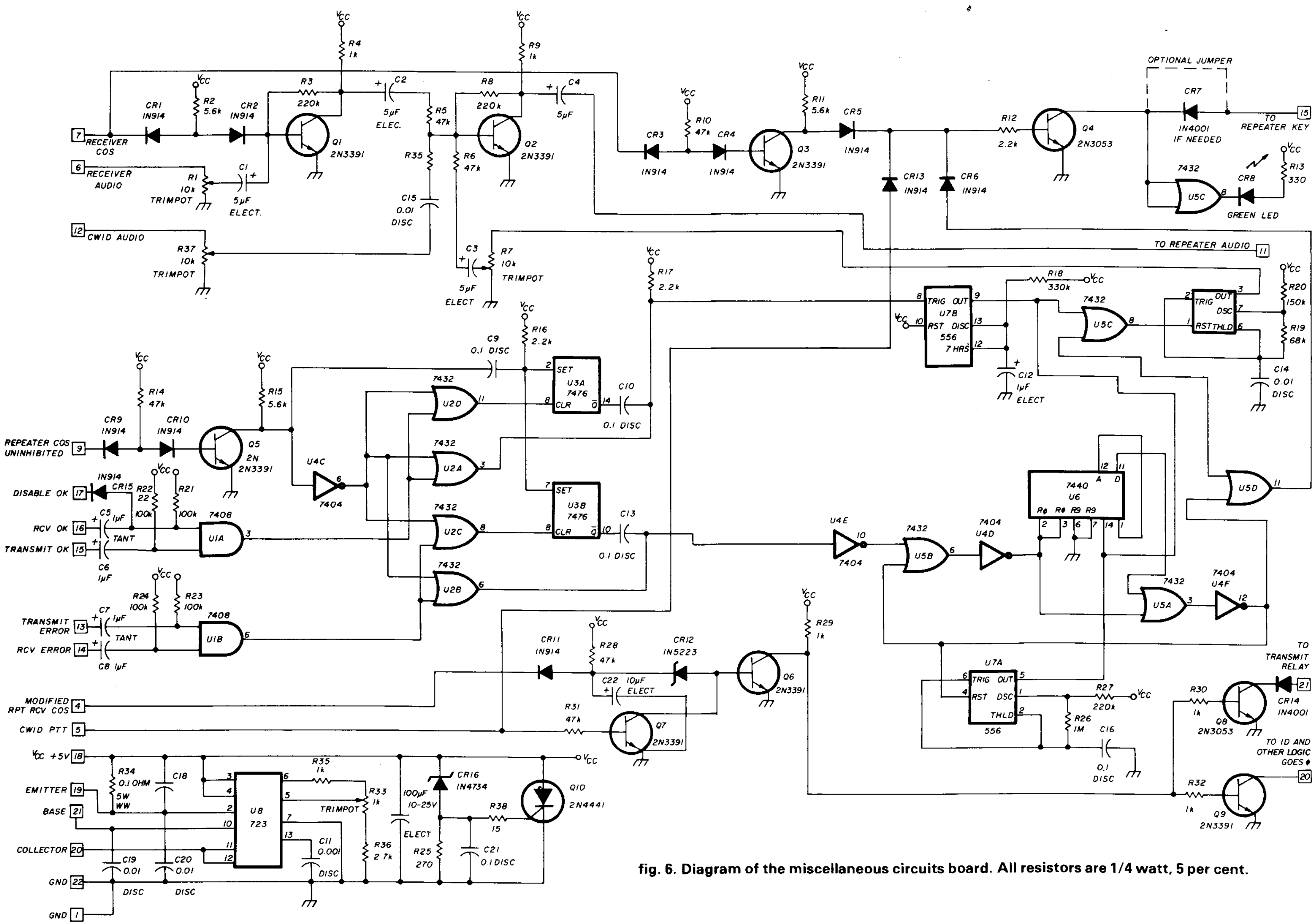
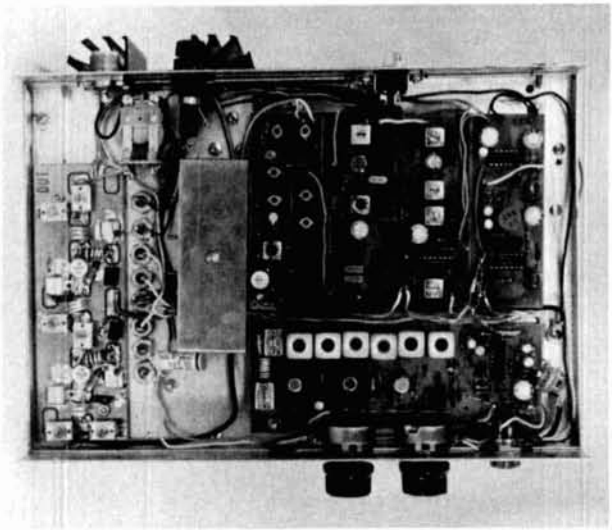


fig. 6. Diagram of the miscellaneous circuits board. All resistors are 1/4 watt, 5 per cent.



Layout of the bottom of the remote synthesized base. At the far left is the 15-watt 144-MHz rf power amplifier; the heatsink is on top of the chassis; enclosure at left center contains the 144-MHz filter. The four circuit boards at top right are, beginning at the left: 144-MHz receiver, 10.7-MHz i-f, 455-kHz i-f, and audio; lower right is the VHF Engineering 144-MHz transmitter strip.

their enable inputs held high by U2C and U2D so the outputs follow the input. Whenever the transmitter is disabled, the okay to transmit (XMT OK) signal from the transmit board goes high, setting U2C and U2D, which causes the data latch enable line to go zero, holding the data at that time. The frequency will be displayed and held and used by the synthesizer as the transmit frequency. The setting of U2C and U2D provides a pulse through U2A and U2B which then triggers the CW ID.

When the ID finishes, it causes a reset pulse to be generated from Q1 through C1 to reset U2C. On an initial transmission, the CW identifier is triggered by a positive pulse generated when U17 toggles. It is set by a pulse generated through C7 when the XMT OK line goes to zero, then resets through C6 the next time the remote base key line is engaged.

The display portion of the board consists of six, 7-segment LED displays. Digits M1 and M2 are hardwired so they always display one and four; the remaining displays are driven through current-limiting resistors and decoder drivers connected directly to the same data bus as the synthesizer. To reduce power consumption, the display is strobed.

To control the data select ICs, the key line to the transmitter is also connected to the input of Q2. When the transmitter is keyed, the input to inverter Q2 goes low; the output is inverted by U5C, which controls the data select chips U14, 15, and 16. When the key is released, Q2 conducts, the green LED (receive) is illuminated, the red LED goes out, and the data select outputs return to the selected receive frequency. The green receive LED is inhibited whenever a valid frequency has not been accessed.

The RCV OK signal is connected to one input of U1A while the other input of U1A is connected to the collector of Q2. The output of U1A, therefore, is held low whenever the RCV OK signal is high (disabled), regardless of the Q2 output.

miscellaneous circuits board

This board, **fig. 6**, contains the regulator chip and the associated components to control the 5-volt pass transistor. Also on this board is the keying control for the remote transceiver, repeater keying control, repeater audio inputs, and signaling generating circuits.

The remote base is keyed by the repeater receiver COS signal after it has passed through the transmitter data latch and control board. The other keying input is the CWID PTT output. The CWID gets it COR input from the output of Q9, which allows it to ID during a series of transmissions. A slight delay in dropping of the remote transmitter is provided by C22 and CR12 to prevent the transmitter from dropping out because of flutter on the 220-MHz input.

Repeater keying is provided from three sources: the remote receiver (COS after it has passed through the receiver data latch and control board), the signaling circuits, and CWID. The remote receiver COS is connected to the inputs of Q1 and Q3 after it has gone through the receiver data latch and control board. When a signal is being received by the remote base receiver, this COS input goes low, Q3 is cut off, and Q4 is driven into saturation.

The CWID PTT is coupled through CR13 and R12 to Q4. When the ID is running, a positive voltage keeps the repeater on the air and allows the ID audio to be heard over the repeater.

The other input to Q4 is from the signaling circuitry through CR6. Whenever one of the control functions has been activated, a signal is returned to the operator through the repeater to let him know the status of his controlling commands. These outputs are connected to U1A for the OK signal, and U1B for the ERROR signal.

When an OK signal is sensed, a short pulse is developed across either C5 or C6 which results in a short zero-going pulse at U1A output. The pulse is connected to gates U2A and U2D. If there is an input on the repeater receiver, it is assumed that the operator is still transmitting, causing the output of Q5 to be high, blocking the pulse output of U2A. Since the output of Q5 is inverted by U4C, the other input to U2D will be low, so when the signaling pulse arrives, it is allowed to pass through U2D and set U3A. When the receiver COS is released, the Q5 output returns low, sending a short pulse through C9 to reset U3A.

When U3A resets it sends a pulse through C10 to trigger U7B.

If there was no input to the repeater receiver when the signaling pulse appears on the output of U1A, the Q5 output would be low, allowing this pulse to pass through U2A and not through U2D, triggering U7B. U7B is a one-shot timer which provides a pulse to operate the tone generator U9, and key the repeater transmitter through U5D and CR6. This results in a short continuous tone to signal that either the receiver or transmitter had been properly accessed.

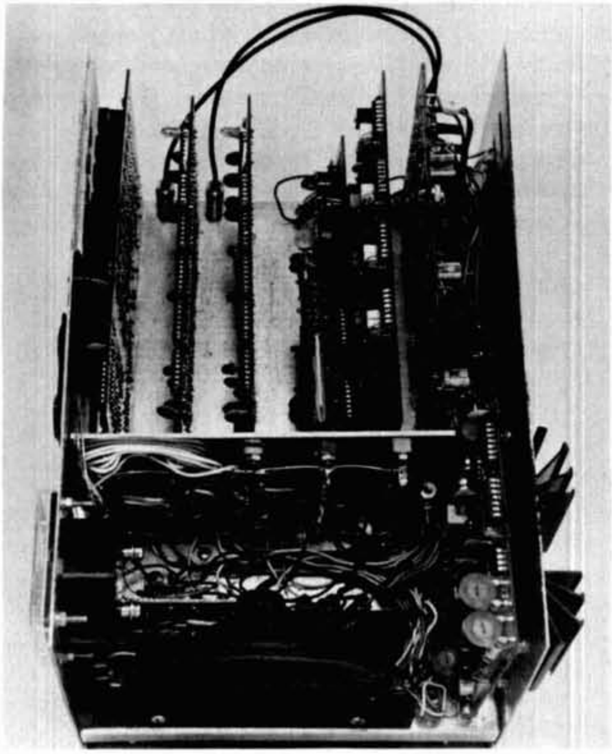
If a valid frequency had not been accessed, however, an ERROR signal would be received on one of the inputs. If there is no input to the repeater, U2B is allowed to pass this pulse to U4E, while U2C will pass the pulse to U3B. U3B will then reset when the repeater is no longer receiving a signal, sending a pulse through C13 to U4E, U5B, and U4D.

When U4D output goes low, U6 counts the pulses from U7A; this output is also coupled through U5C to the tone generator U9 to provide a series of dits. Once started, the BCD 8 output on the counter will go to zero. This level is connected to one of the inputs of U5A; the other U5A input is from U4D which went zero with the signal-starting pulse. With both inputs at zero, the U5A output is zero. This is inverted in U4F and connected to the other U5B input. This allows the counter to cycle through to the eighth count where the output again goes high, causing U5A output to go high, eventually stopping counter U6. The U4F output is also used to stop the pulse generator U7A and key the repeater transmitter through U5D, CR6, and Q4.

Audio from the remote receiver is connected through R1 to Q1, which is controlled by the receiver COS. This blocks the receiver audio when an invalid frequency has been selected or the receiver has been disabled. The Q1 output is coupled through C2 and R5 into Q2. The output of the signalling generator U9 is also connected through R7, C3, R6 to Q2, while the CWID is coupled through C15 and R35 and R36 to Q2. This allows independent adjustment of the receiver, ID, and signalling audio levels.

construction

The remote base was built into an LMB cabinet (W-2J). The receiver, a VHF Engineering RX144B, was assembled according to the manufacturer's instructions, with the exception of a modification to make the COS output go low upon the receipt of a signal. This strip is mounted on the underside of the chassis as shown in **fig. 7**. Two small potentiometers were added to the VHF Engineering TX144B transmitter for the line and mike inputs so that both the levels and the deviation limit could be set. A VHF Engineering PA144-15 power amplifier was used,



Top of the synthesized base showing circuit board placement; boards, left to right, are data select and display, transmit data latch, receive data latch, two-digit access, CW ID, touch pad decoder, and VHF Engineering synthesizer. Miscellaneous circuits board (fig. 6) is at lower right next to the heatsink (on rear panel) for the 5-volt regulator. Heatsink for the power amplifier stage is hidden by the speaker in foreground.

although the PA144-25 will also work. The amplifier was mounted with its heatsink on top of the chassis and the printed-circuit board with the components below the chassis (see **fig. 7**). The double-pole, double-throw relay (Magnetcraft W88X-7) mounted next to the antenna connector is used to switch the antenna and the 12-volt supply between the receiver and transmitter.

The receive and transmit oscillator signals are fed through phono connectors located on the opposite side of the receiver. The volume and receiver squelch controls are mounted between the exciter and front panel.

The tone-pad decoder board, two-digit access and control board, data latch boards, data select and display board, miscellaneous circuit board, and the CWID and synthesizer are all mounted on the top side of the chassis. A heatsink (Wakefield 641-Z) with the 2N3055 5-volt regulator transistor is mounted on the rear panel behind the miscellaneous circuit board; the 9-volt and 5-volt regulators for the synthesizer are mounted without heatsinks on the other side of the rear panel.

The VHF Engineering SYN II synthesizer board was assembled according to the manufacturer's instructions with the exception that resistors R1 through R12 and R14 were not installed. The offset-programming diodes, CR3 through CR8 are not needed.

The eight feedthrough capacitors are used for the following items (listed in order from the front to the rear):

1. Local mike PTT
2. Transmit/receive relay
3. Transmit audio
4. 13.6-Vdc supply
5. Receiver audio
6. Receiver COS
7. Receiver speaker
8. Optional S-meter

When stuffing the two-digit control board (TDC 203), the control codes should be chosen and programmed; I used 71 (R1) for receive, 81 (T1) for transmit, and 73 for disabling.

installation and interfacing

The 2-meter base was connected to a VHF Engineering 220-MHz repeater. The repeater COS (low state on) from the COR-2 board (PTT), along with the audio from the repeater speaker line, are connected to the audio and COS input lines of the remote base. Initially the installation was made at a site which contained one 2-meter repeater and another 220-MHz repeater. In addition, there is a 2-meter repeater located approximately 0.4 km (1/4 mile) from the remote base. The major problem is with the 2-meter repeater located at the same site as the remote base, although some interaction (desense) also occurs when the other 2-meter repeater is in use. Based on these experiences, I recommend that the remote base not be co-located with a 2-meter repeater. I also recommend that the 220-MHz and 2-meter antennas be located one above the other on the tower.

operation

For maximum versatility the system was set up to allow separate dialing of the receive and transmit frequencies. To dial the receive frequency, dial R (7 on the tone pad) and the frequency desired, R147.340 for example. After the mike PTT has been released, a short continuous tone will be heard, indicating that the frequency has been successfully accessed (a short burst of dots indicates the operator was unsuccessful). When a valid receive frequency had been accessed, any signals appearing on the remote receiver input will be heard on the 220-repeater output.

Once a frequency has been selected, then the appropriate transmit frequency, simplex or repeater input, can be dialed starting with T (digit 8) and the frequency, T147.940 for example. Again, shortly after the mike key has been released, a signalling tone should be heard which indicates either success or failure. If it's success, any signals appearing on the input to the 220-MHz repeater will be retransmitted on the selected 2-meter transmitter frequency.

When the transmitter is used on a new frequency, it will transmit its ID on both the 2-meter remote base as well as the 220-MHz repeater. The ID will reoccur periodically during a series of transmissions at a rate set by the control operator.

After a QSO is complete, only the transmitter can be dropped, allowing the operator to monitor any last comments from others by dialing the transmit access code T1 (81), but no additional digits. When this is done, the transmitter starts to reprogram, but since a valid complete frequency is not received, a misdial (error) is sensed and an ERROR signal is returned; the transmitter identifies on the last frequency it used and is then disabled, leaving the receiver on. The receiver can be dropped by dialing the access code R1 (71) and no further digits. The code 73 will drop both the receiver and transmitter and return an OK signal indicating successful receipt of that command; this causes the remote transmitter to identify a final time on the last frequency it used.

current result and the future

The prime purpose of this project was to encourage the use of 220 MHz by Amateurs in the Atlanta area. Though the selection of 220-MHz rigs available is currently limited, I hope the demand for equipment will stimulate an abundance of gear with the many bells and whistles that are now available on 2-meter rigs.

Over a year ago there were two 220-MHz repeaters on the air in the Atlanta area and only four people using them; six months ago two more operators became regular users but I was unable to convince others to invest in 220-MHz equipment. Since the remote base has been on the air, about fifteen new operators have been added to the list, and this was before demonstrations were given to the Kennehoochee Radio Club and the Atlanta Radio Club.

acknowledgments

I would like to thank the following Radio Amateurs who helped assemble the prototype remote base, and who provided valuable suggestions and help in preparing this article: W. C. Clonninger, W4NX; Dave Rogers, AA4DR; Boyd Cone, AG4X; and Jack Sanders, WB4CDP. Also to Judi, my very best friend, who not only assembled most of the remote base but also typed the manuscript for this article.

ham radio

portable monoband shortwave receiver with electronic digital frequency readout

I have previously expressed my views on the advantages of monoband receivers.[1,2] This article describes my latest effort in this regard. A portable receiver design is shown with digital frequency readout. The front end covers 2.3-6.5 MHz without bandswitching. Frequency coverage can be extended by changing the rf and mixer coils. Two frequency-display options are offered depending on the i-f chosen; these are dubbed GP-58 and GP-59. The receiver weighs about 3.4 kg (8 lbs.), uses about $250 worth of parts, and required about 450 hours to build.

general considerations

My sets are designed for portable operation, so size and power consumption are of prime importance. Although frequency readout with mechanical counters is attractive, much design and construction difficulty occurs. Judging from reader response to earlier designs,[3] many prospective builders lacked facilities to homebrew a set with mechanical digital frequency readout within the standards set forth.

With the advent of electronic frequency counters designed around CMOS ICs,[4] it's possible to read frequencies with an extremely low current drain, which makes this method of frequency measurement suitable for battery operation. The physical size of CMOS counters is also quite small, and they require fewer components than the older TTL devices.

designs

If you're interested in receiving signals below 10 MHz (as in my case), frequency readout is extremely easy to implement by using a 9-MHz i-f. The MHz digit is read on the VFO bandswitch knob and the kHz numerals are read on the counter display (**fig. 1**). The VFO frequency (12.015 MHz) is set equal to the received frequency plus the i-f.

Note that, using this design option (the GP-58), the readout is entirely digital yet only three LED displays are used. Counter current drain is reduced to a bare minimum. The 9-MHz crystal filter is available for about $50.00.

An alternative design (the GP-59) employs electronic digital frequency readout by using a 10-MHz i-f (**fig. 2**). This option offers more convenient frequency readout but at the price of more battery drain and a custom-made 10-MHz filter. The 10-MHz crystal filter is available in the U.S. on special order for about $80.00. It can be home built.[5,6] The filter in reference 6, which I've tried, is particularly attractive. It uses standard 10-MHz crystals.

A word of caution if you're planning to use the 10-MHz i-f: Some performance degradation may occur because of WWV signals feeding into the 10-MHz i-f strip. The receivers are well shielded and use a trap tuned to the i-f in the front end, but isolation may not be sufficient where the WWV 10-MHz signal is particularly strong. In this case more elaborate shielding may be required.

Despite the fact that the VFO operates in the 10-20-MHz region, extremely stable operation occurs. (Sta-

By Jack Perolo, PY2PE1C, P.O. Box 2390, São Paulo, Brasil

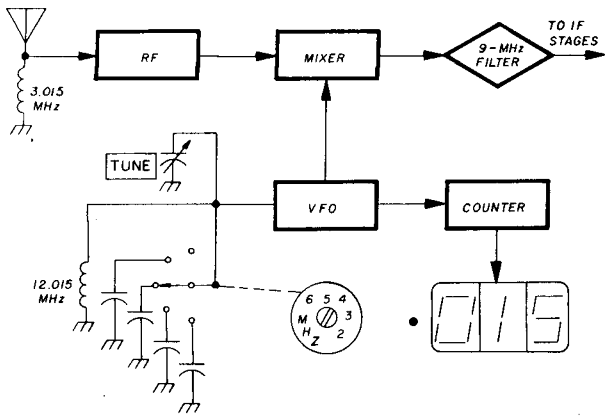


fig. 1. Electronic digital frequency readout using a 9-kHz i-f. Received signal is 3.015 kHz.

bility, sensitivity, and avc response are shown below.)

construction

The photos show the GP-58 receiver and give details for its duplication. A schematic is provided in **fig. 3.**

Cabinet dimensions are 140 x 65 x 160 mm (5.5 x 2.5 x 6.5 inches). Cabinet material is 16-gauge stainless steel. The cabinet was formed on a steel press. The main chassis and back panel are of 3.2-mm (1/8-inch) aluminum. All shields are of 0.8-mm (1/32-inch) thick aluminum. The PC boards are mounted on 6.4-mm diameter (1/4-inch) pillars fastened with M3 (4-40) allen screws.

coil*	description	frequency range (MHz)
L1	18t on 5-mm (3/16-in) slug-tuned ceramic form	9.0
L2, L3	6t and 55t respectively (Amidon T37-2 toroid)	2.3-6.5
L4	55t (Amidon T37-2 toroid)	2.3-6.5
L5	18t on 6.5 mm (1/4-in.) slug-tuned nylon coil form	9.0
L6	42t on 6.5-mm (1/4-in.) slug-tuned nylon coil form	9.0
L7	18t on 6.5-mm (1/4-in.) slug-tuned nylon coil form	9.0
L8	18t on 6.5-mm (1/4-in.) slug-tuned nylon coil form	9.0
L9	6t on 6.5-mm (1/4-in.) slug-tuned nylon coil form	9.0
L10	10t on 5.0-mm (3/16-in.) slug-tuned ceramic form	11.3-15.5

*all coils are wound with 0.3 mm (no. 28) enameled wire

Knobs are by National (Raytheon makes a similar design). The antibacklash gear reducer is a British import with a 1:100 ratio; the manufacturer is Muffett, Ltd. The VFO capacitor is also a British import (Windgrove and Rogers). The S-meter is a Japanese import with a 1-mA movement. (The original dial was replaced to show S-meter readings.)

The 9-MHz crystal filter is available from Yaesu dealers. Its bandwidth is 2.4 kHz at −6 dB. The i-f coils are made in Brasil and are about 15 x 15 mm (0.6 x 0.6 inch) with a 6.4-mm (1/4-inch) internal coil form.

power supply

The power supply accepts both ac and dc. It has been designed for portable operation, in which the display can be switched off to reduce battery drain. You can use a 12-volt ac supply or a 12-13 volt dc source rated at 100 mA. Current consumption at 12 volts dc is 85 mA with the counter on and about 45 mA with the counter off. For portable use I operate this set with a calculator power supply. The 13-volt zener is a surplus item and, being of nonstandard voltage, may be difficult to find. A 12-volt zener could be used.

devices

The digital displays are Fairchild FND-357. ICs 7207 and 7208 are by Intersil (described in reference 4). Note that the 7207A is *not* a replacement for the 7207. The 74LS90 is a standard low-power Schottky device available from many sources. Transistors BF-255, BD-135, and BD-136 are Siemens; BF-115 is Phillips. All other transistors are of U.S. manufacture.

performance

With the filter shown (bandwidth 2.4 kHz at 6 dB down), overall sensitivity was measured at slightly over 122 dB (while receiver tuned to 4.9 MHz):

front end and mixer	14 dB (including filter loss)
i-f strip	70 dB
audio section	38 dB

Operation is stable for the input-voltage range of 12-8

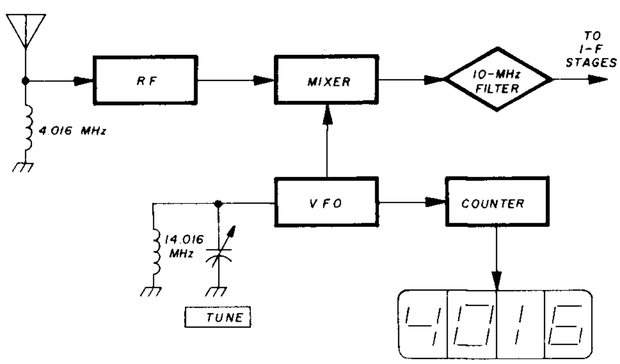


fig. 2. Electronic digital frequency readout using a 10-kHz i-f. Received signal is 4.016 kHz.

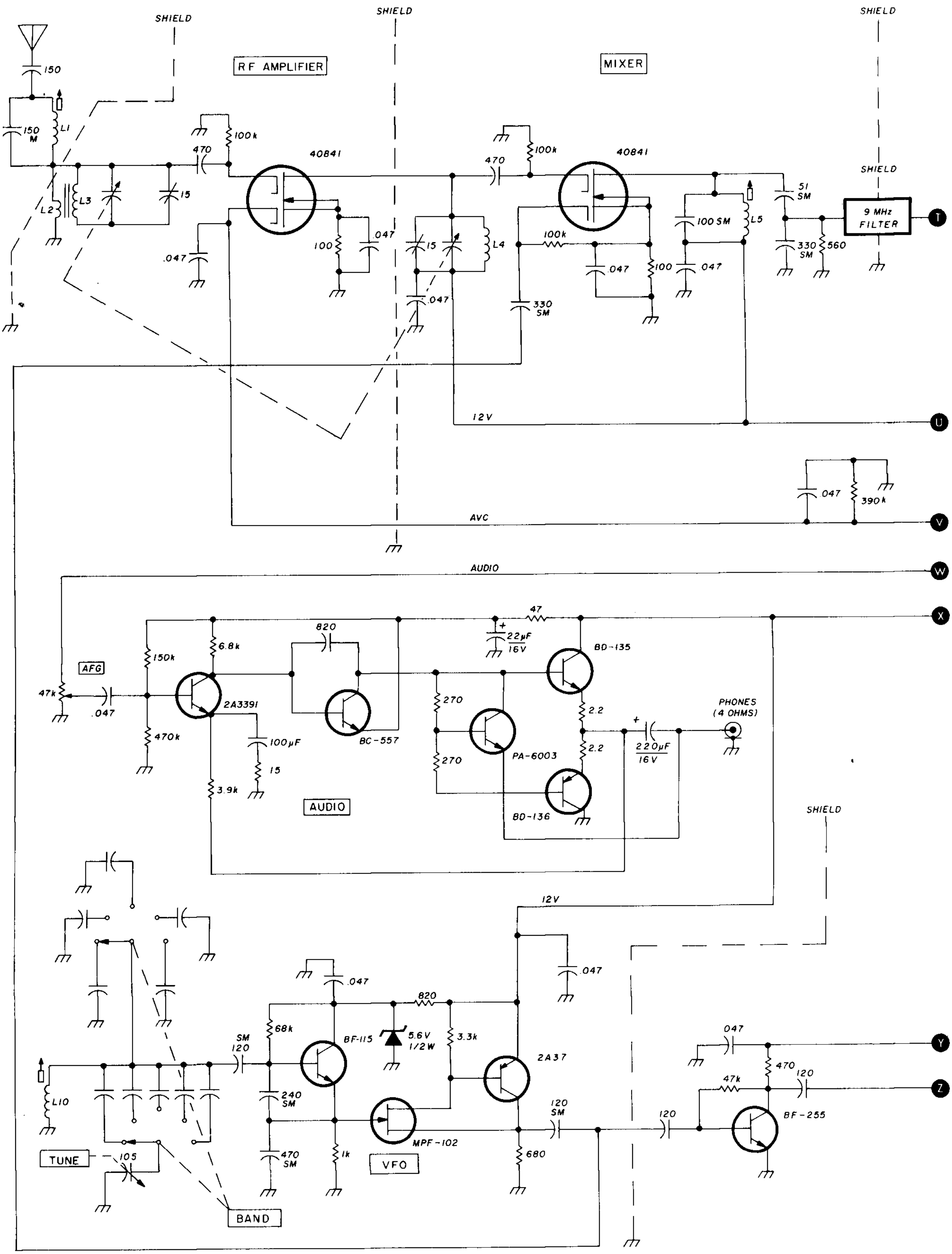
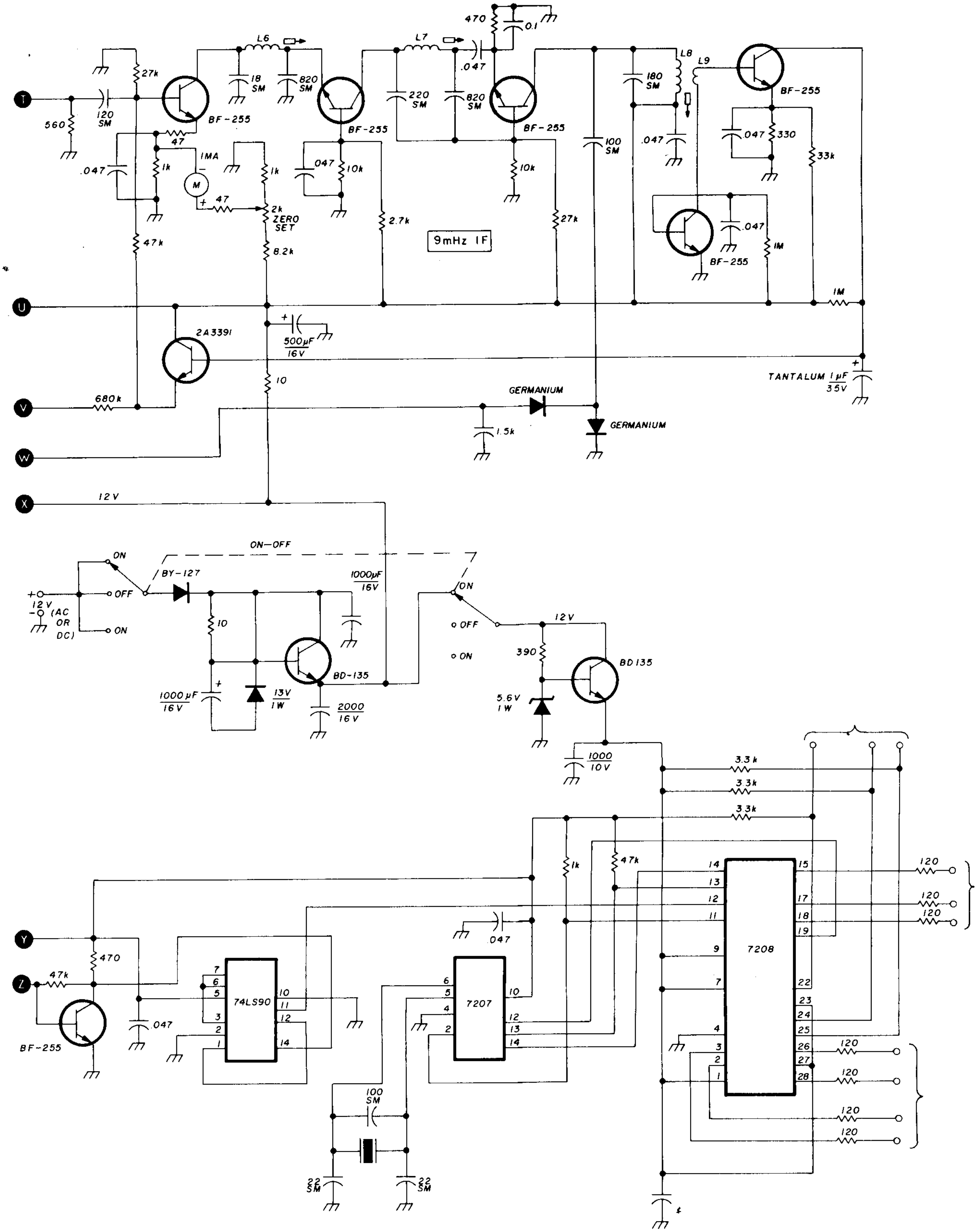


fig. 3. Schematic for the portable shortwave receiver covering 2.3-6.5 MHz. (See text for other frequency ranges.)


9mHz IF
BF-255
L6
L7
L8
L9
2A3391
BD-135
BD135
BY-127
GERMANIUM
TANTALUM 1μF 35V
1MA
2k ZERO SET
ON-OFF
12V (AC OR DC)
74LS90
7207
7208

volts. *At about 7.5 volts the counter becomes* unstable. Desensitization becomes noticeable below 9 volts, with overall gain dropping to about 100 dB.

Worthy of mention is the fast-attack, slow-release avc response (also measured at 4.9 MHz):

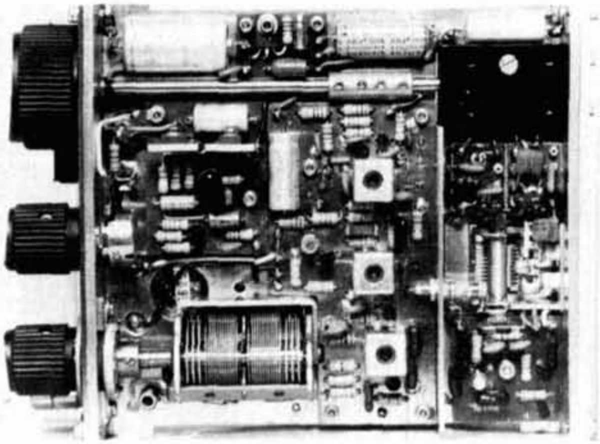
input signal (mV)	output (mV)
125	275
20	275
2	200

Counter frequency stability is excellent. Operation to 18-19 kHz was stable and reliable. (These are my qualitative observations; they were not checked specifically.)

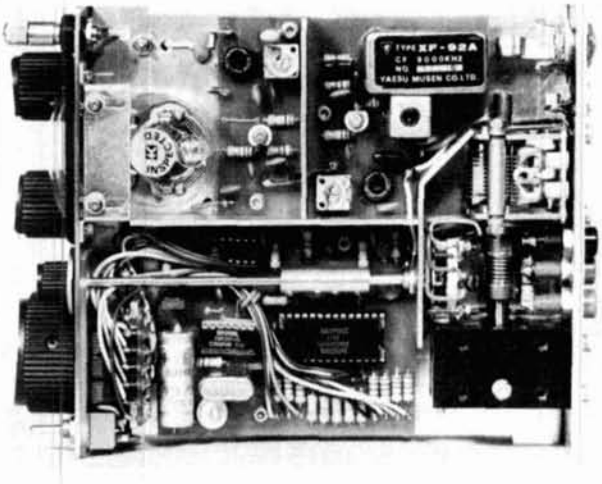
Overall stability was measured with a laboratory frequency meter. After a 5-minute warmup (radio tuned to 6.2 MHz), the frequency did not vary more than ±25 Hz during a 15-minute period. The key to such performance is to operate the VFO transistor with V_{cc} at only 5.6 volts while selecting the best capacitive feedback ratio (see **fig. 3**).

conversion to other frequencies

This set was designed for shortwave broadcast listening between 2.3 and 6.5 MHz; the Amateur 80-meter band is therefore included. The Amateur 40-meter band could be covered by appropriate changes to the rf and mixer coils. For higher-frequency Amateur bands the VFO range will probably exceed the counter upper-frequency response. *This problem* could be cured either by adding a prescaler to the counter or by running the VFO below the input frequency. Note that VFO operation above 10 MHz requires the first two digits to be shown on the bandswitch knob rather than only one digit as shown in **fig. 1**.



Bottom view. The 12-volt regulated power supply is at top above the tuning shaft. The af amplifier is at center left. The rf 2-gang tuning capacitor is at bottom left. Below is the 9-kHz input trap coil. The i-f double-sided PC board is in the center. The tuning gear reducer is at top right; below it are the padder and trimmer fixed capacitors, the VFO variable capacitor and VFO coil, and the VFO board (bottom right). A shield separates the VFO from the i-f board.



Top view. At top left, near the S-meter, is the rf amplifier board; *at top right is the mixer board* with the 9-MHz crystal filter and matching transformer. The VFO variable capacitor is at center right. Toroid coils are seen for the rf and mixer stages. Below the VFO capacitor is the VFO bandswitch and the tuning gear reducer. At bottom left is the CMOS frequency counter, which is completely shielded from all other stages. On the frequency-counter board above the bandswitch shaft are the 74LS90 IC preceded by the two amplifier stages (BF-255). The 5-volt regulated power supply is at top left near the 1000-μF electrolytic capacitor, which is partially hidden by the cable harness.

final remarks

I used particular care in this design to maintain low current drain without sacrificing performance. The LED displays are visible using a 120-ohm series resistor as shown in **fig. 3**. The af strip was adjusted for headphone operation with low quiescent current (about 12 mA), yet it can deliver peaks of over 2 watts into a 4-ohm load.

acknowledgement

I am deeply indebted to Maiso, PY2GP, for his support and to Fernando, PY2DQU, who helped with *much design work and measurement equipment.*

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ham radio

solid-state
vhf linear amplifiers

With the increasing use of single sideband on 2 meters and above, more solid-state linear amplifiers are being built. The power range of these amplifiers has been extended into the 80 to 100 watt per transistor package class. However, a major difficulty occurs since the existing market is almost exclusively class C (land-mobile fm), with no linearity requirement; Amateurs want the ruggedness of the land-mobile components, with the additional features of linearity and 4-MHz bandwidth.

distortion products in linear amplifiers

Amplifiers have been in use since the inception of Amateur Radio. The term "linear" is a precise term describing the output waveform as being a constant multiplied by the input. Since only "approximately linear" amplifiers are available to us, we generally limit the term *linear* to amplifiers which have odd-order mixing (intermodulation) products 30 dB or more down from peak power. This figure was derived in the early sixties by power tube engineers at Eimac; they determined that with intermodulation products down 30 dB, an Amateur would cause minimal disturbance to an adjacent channel; the industry currently specifies most high-frequency equipment near this standard. However, in the vhf range, many solid-state amplifiers exhibit intermodulation distortion products similar to that of a class-C amplifier. In fact, one amplifier tested showed near identical intermodulation performance with or without forward bias.

causes of nonlinearity

The sources of nonlinearity can be related to three major areas in bipolar semiconductors: the input, the transfer function, and the output. The input characteristics are affected by two components: the base-emitter diode and the base resistance. The base-emitter diode will function as a detector or mixer. This nearly-ideal diode responds as predicted by the diode equation with a full set of harmonics and mixer products when driven by a sinusoidal input. The base resistance also changes in a nonlinear fashion because of base-width modulation and resistivity changes by heavy injection of minority carriers. However, these changes are masked somewhat by the effects of the base-emitter diode.

The second problem area is the transfer function, the variation of h_{fe} with current. This variation is dependent upon the device-doping profiles which are fixed by the semiconductor manufacturer. High-frequency (2-30 MHz) linear components show less change in h_{fe} than do the class-C parts we must use on 2 meters.

The output characteristics of the transistor are a third source of intermodulation products. These relate to the junction capacitances and the voltage across the junctions. Fortunately, the output characteristic contributions are minor when compared with the total problem.

Fig. 1 shows a transistor model that I borrowed from Amprex which illustrates the effects and contributions of the various components. Note that I have added an input T network similar to the input of a JØ packaged rf power device.

optimization of linearity

The two predominant areas, within the design, that control linearity are choice of operating point and the matching networks. The base-emitter diode is not practical because of series impedances within the transistor package; high emitter currents reduce distortion by reducing the applied signal voltage across the diode. The emitter resistance, R_e, will contribute to this effect as does the package inductance. Increasing the collector current excessively will slide the operating area into the saturation region where the nonlinear transfer effects (h_{fe}) will predominate. I have found that close attention to this detail and presenting the proper load impedance to the transistor will provide acceptable IMD products.

By Charles F. Clark, AF8Z, 3720 Blue Mound, N.E., Cedar Rapids, Iowa 52402

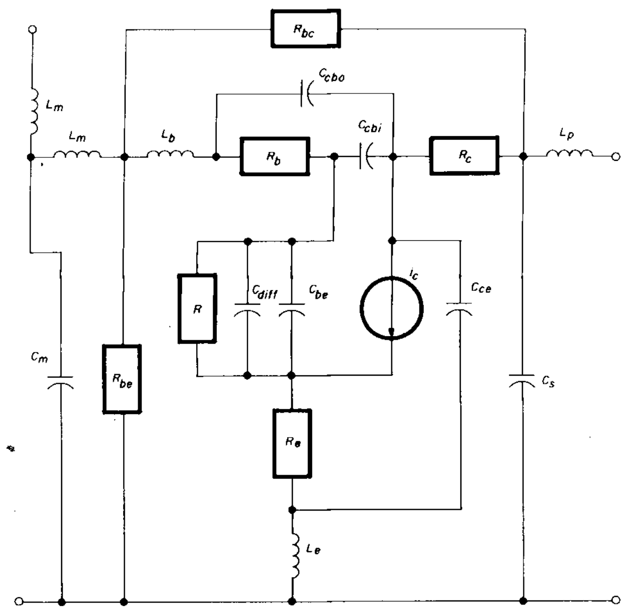


fig. 1. Equivalent circuit of a JØ packaged rf transistor in the common-emitter configuration. In addition to the basic model described by Amperex, the author has added a T network at the input to approximate the JØ package.

biasing

The biasing of vhf power devices should be the same as that of high-frequency devices. The characteristics of this bias source should include a thermal cutback, to prevent a shift of the operating point when the transistor die heats up, and a low-impedance, constant-voltage source. These seemingly contradictory requirements are created by the drop in base-emitter voltage with temperature and the rectification of drive in the base-emitter junction. A typical 80-watt high-frequency device might experience a 200-mA change in base-current drive requirements because of this effect. These changes make the paralleling of devices even more difficult than at high frequencies. If you must parallel devices, match V_{BE} (on) and h_{fe}.

practical bias circuits

There are many bias circuits which meet the following two requirements: the dc base voltage is constant with rf drive level variations, and the dc base voltage decreases as die temperature rises within the package. The diode clamp and Byistor are two extremely similar circuits which meet these requirements. The Byistor offers superior protection from thermal runaway because the increase in voltage drop across the silicon resistor lowers the bias voltage. The diode clamp, without the series resistor, offers a lower source impedance. The Byistor has an output impedance of about one ohm. The current required for the diode clamp does not change appreciably over the operating cycle (see **fig. 2A**). The base current requirement can be in the 200 to 400 mA area.

A reduction in current requirements may be obtained by using a series, rather than a shunt, regulator. The simplest is a diode clamp circuit feeding the base of a pass transistor (see **fig. 2B**). A second series diode is added to compensate for the base emitter drop of the emitter follower. This reduces the current required from the diode source by $1/h_{fe}$. Single-transistor amplifiers work well, as demonstrated by the circuit from Amprex shown in **fig. 2C**. The variable resistor is used to set the output voltage. This circuit has an output impedance of approximately 0.1 ohm for a 360-mA current variation.

Operational amplifier circuits provide even lower output impedances and may feature current limiting and an even greater range of operating points (see **fig. 2D**). If you are interested in superior performance, this type of circuit is appropriate.

bias circuits precautions

Always begin experimentation with minimum bias voltage. The h_{fe} of rf devices designed for class-C

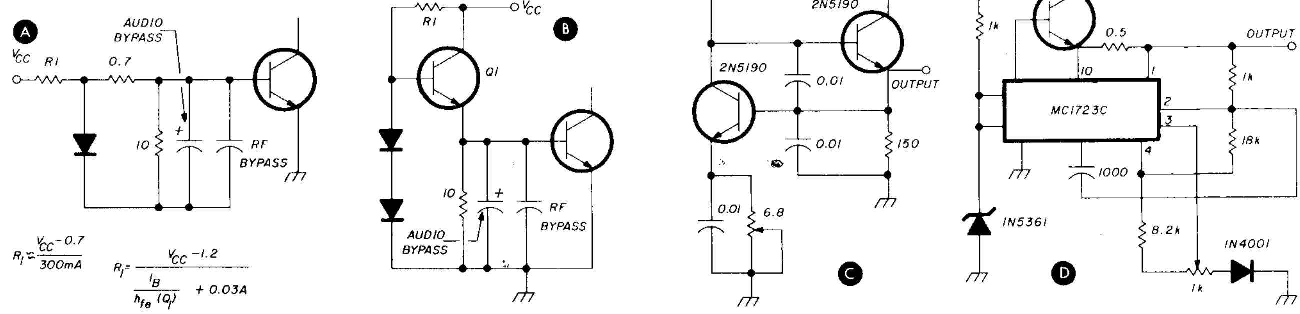


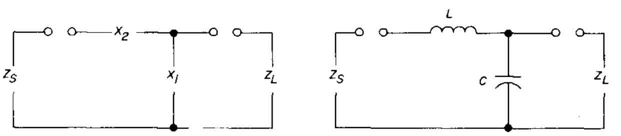
fig. 2. Four different methods for supplying base current. (A) illustrates a simple diode clamp/Byistor circuit. The Byistor provides superior thermal runaway performance. By changing to the series regulator (B) instead of shunt regulators, the current requirement is reduced by $1/h_{fe}$. (C) shows another version which incorporates a simple transistor amplifier. This circuit, along with (D), is an active bias supply which features high current capability and low output impedance.

operation varies widely, unless specified at a certain value. The bias voltage may be set at a fixed value once the desired current is determined for a specific transistor.

Mount the temperature sensor to the rf transistor's package for maximum protection against thermal runaway. The second best is to mount the sensor on the heatsink near the rf transistor. *Never* expect protection against thermal runaway if the diode or transistor sensor is floating with its leads in the air.

L-network matching

Input and output impedance matching can be performed by using a series of L-matching sections. The L match (see **fig. 3**) is a minimum Q match and is ideal for matching across an entire Amateur vhf band. The maximum impedance transformation should be less than 5:1, if possible. A 10:1 transformation, however, may be possible with real world components, if care is used.



$$X_1 = \frac{R_S X_L}{R_S - R_L} \pm \sqrt{\left(\frac{R_S X_L}{R_S - R_L}\right)^2 - \frac{R_S(X_L^2 + R_L^2)}{R_S - R_L}}$$

A

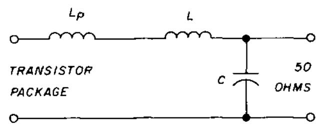
$$X_2 = \frac{R_S(X_1 + X_L) - R_L(X_1 + X_S)}{R_L}$$

L NETWORK MATCHING EQUATIONS

B

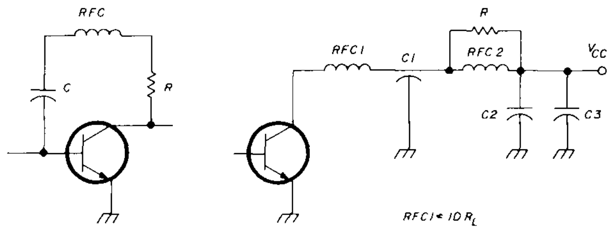
fig. 3. Schematic diagram of an L network and the necessary design equations. The lowpass prototype at the output of the transistor provides additional harmonic filtering which may make additional filters unnecessary.

When matching the output of the transistor to 50 ohms, a lowpass matching section reduces the required filtering at the output of the unit. My experience has shown that harmonic levels will be approximately 40 dB down, without additional filtering. The design of the first L-matching section is performed with the package inductance in mind.



low-frequency stability

Low-frequency oscillations can occur between several hundred kHz and several MHz if suitable precautions are not taken. These oscillations are quite troublesome, and the high low-frequency gain of the device and the mismatch presented to the collector can cause thermal runaway and destruction of the transistor before the thermal foldback can prevent runaway. Therefore, design must guard against this possibility by either bypassing the collector in a suitable fashion or using a feedback network that kills gain at the low frequencies.



RFC = 10R_L
C = LOW HIGH FREQUENCY BYPASS
R = AS REQUIRED

RFC1 = 10 R_L
RFC2 = 10 R_L
R 100 OHMS
C1 = SERIES RESONANCE
C2 = HIGH FREQUENCY BYPASS
C3 = AUDIO BYPASS

The networks shown above will cure most problems caused by the classical modes of oscillation. As an aid, here are some basic rules of thumb that can be used to rate different rf transistors and the low-inherent frequency stability:

1. Low frequency gain should be as low as possible (low h_{fe}).

2. Emitter resistance or inductance decreases gain and therefore increases low-frequency stability.

3. High collector resistivity lowers gain.

This sums up the low-frequency stability problems; other new problems, however, crop up with the increase in gain to linear circuits — vhf parasitics. The parasitics are due to excessive emitter inductance and feedback from the collector forming a grounded-base oscillator. These oscillations may be killed by a further increase in emitter inductance, with the resulting loss of gain, or by a reduction in emitter inductance and a gain increase. It is wise to note that 3.2-mm (1/8-inch) increases on all four emitter leads of a JØ package will cause a 3-8 dB decrease in gain; it is possible to get only 8-10 dB at best. Obviously, decreasing the emitter inductance is a superior course of action. This can be done by

1. Using copperfoil to strap the grounds of the printed circuit board together, or using eyelets to do the same.

2. Mounting the base-to-emitter and emitter-to-collector capacitors on top of the transistor leads.

This mode of oscillation is supported by the output matching network and from computer aided analysis seems to be present in all the matching networks I've compared. One way to determine if this is the case in your amplifier is to add additional capacitors to the base circuit; if you still draw excessive collector current, the chances are you have a common-base oscillator.

ham radio

More Details? CHECK—OFF Page 110

amateur radio equipment survey
number two

If you have read the results of our User's Survey on the Drake Twins in the December, 1979, issue of *Ham Radio Horizons*, it's almost a sure bet that you are ready to give us your thoughts on some equipment that you own, or have used.

Well, here's your chance — if you own a Heath HW/SB-104, a Ten-Tec Triton IV, or a Yaesu FT-101B (or later).

I know, from looking at equipment advertisements in classified sections, from comments made on the air, and from correspondence, that there are sizeable numbers of each of these rigs in use in the Amateur world, so your reponse should be a pretty fair cross-section of opinion about these three rigs. Look carefully at the letter suffix on the FT-101, if that's your rig. I'm limiting the questions to those with a suffix of B, or later, because the first FT-101s on the market were not really the same as the later ones. The engineering changes in more recent 101s were sufficient that they're almost different rigs, at least as far as operating problems and servicing are concerned. Also, here's your chance to sound off about a rig you may have assembled — the HW-104 or SB-104.

There's a space for you to give the Instruction/Assembly manual a rating, which will prove useful to newcomers who want to build a rig, and to manufacturers who print manuals and instructions.

Now, about that rating system . . . It was very clear, as I tabulated the results of Survey Number 1, that it was too easy. People who "loved" their Drake equipment just jotted down a 10, while those who had many problems of one sort or another gave it a rating of 1. The histograms with the report in this issue reflect this; the "weight" is all at the upper end of the scale. Accordingly, I've changed the rules just a bit, and you'll have to spend a few more seconds thinking about your rig before you give it a number. For instance, 10 now means the rig is perfect. (If an overwhelming majority of the answers indicate any one particular rig is *perfect*, I'm going to start wondering about some of the "good deals" I've been conned into!)

Other revisions on the form simply removed a somewhat redundant question, as in the case of "Best Feature," and "Why?" Most of the respondents named the best feature and told why in one long paragraph, or else they knew *what* the best feature was, but couldn't find the right words to explain *why*. The same goes for "Worst Feature."

These changes also leave a bit more room in the next question for an explanation of troubles.

Plans for future User's Surveys call for a trio of vhf rigs, and then some more high-frequency types. By that time, there should be a fair population of the newest crop of rigs in use, such as the TR-7s, the 901s, the Omni D, and many others that came on the market in late 1978 and 1979.

It's going to be an interesting winter — and I may have to learn to use a minicomputer in self-defense. Fill out the form, and drop it in the mail right away. Here's another change you'll notice — our address is given at the bottom of the second page, thanks to several of you who suggested that we print it on the form.

ham radio

By Thomas McMullen, W1SL, Managing Editor, *Ham Radio Horizons*

HAM RADIO HORIZONS

Owner Report on Amateur Radio Equipment

(Fill out this form in accordance with your experience. Please type or print clearly.)

1. Make and Model (circle *one* only) Heath HW/SB-104 or 104A Ten-Tec Triton Yaesu FT-101B (or later)
2. What year did you buy it?__________ New?__________ Used?__________
3. Where did you buy it? Dealer__________ Mail Order__________ Individual__________ Flea Market__________ 800 Number__________ Other__________
4. Would you buy from the same source again?__________
5. Amount of use: Daily__________ Often__________ Occasional__________ Seldom__________
6. Is this your primary__________ or backup__________rig?
7. What modes have you used? CW_______ SSB_______ RTTY_______ SSTV_______ AM_______ Other_______
8. Heath HW/SB-104: Did you assemble it? Yes_______ No_______
9. What is the rig's best feature? ____

10. Worst feature? ____

11. Have you had any problems?__________ Explain ______________________________

12. Have you had the rig serviced?__________ Where? Manufacturer__________ Dealer__________ Other__________
13. Was the service satisfactory? Yes__________ No__________
14. What accessories have you purchased for this rig? ______________________________
15. Have you been able to obtain all the accessories and parts you need? ____________________

16. Have you been satisfied with these accessories? Yes__________ No__________

17. If not, why? ____

____

____

____

18. Additional features you would like to see built into a rig of this type ____________________

____

____

____

19. Give the equipment a score from 1 to 10 (with 1 being poorest, 4 to 6 average, and 10 perfect).

Ease of operation ____________________

Reliability ____________________

Durability
(in continuous use) ____________________

Instruction Book
(Assembly Manual) ____________________

Factory/Dealer Service ____________________

Quality of Workmanship ____________________

Performance ____________________

Maintenance ____________________

Parts Availability ____________________

Accessories
(ease of connection) ____________________

Price ____________________

Flexibility ____________________

20. How long have you been licensed?__________ Your Age__________ License Class ____________________

Principal activities: Contest__________ DX__________ Rag Chewing__________

Traffic Handling__________ Experimenter__________

21. What antenna do you use most? Beam__________ Wire__________ Vertical__________ Other__________

22. What rig would you like to see reported on in the future? ____________________

23. Would you buy this same rig again? ____________________

24. (Optional: fill in the following only if you wish.)

Submitted by: Name ______________________________ Call__________

Address ____

City ____________________ State__________ Zip__________

____
(Signature)

(Your signature authorizes *Ham Radio Horizons* to quote portions of your comments in our report.) May we use your name and/or call?

Yes__________ No__________

Note: If you own more than one of the rigs indicated, please write to us for additional copies of this form. Use a separate form for a report on each rig.

Completed survey forms must be returned no later than January 31, 1980, to be included in our report.

Mail To: Ham Radio Horizons, User's Report No. 2, Greenville, NH 03048

Low Cost...High Performance

DIGITAL MULTIMETER

$99.95 WIRED

Low cost, high performance, that's the DM-700. Unlike some of the hobby grade DMMs available, the DM-700 offers professional quality performance and appearance at a hobbyist price. It features 26 different ranges and 5 functions, all arranged in a convenient, easy to use format. Measurements are displayed on a large 3½ digit, ½ inch high LED display, with automatic decimal placement, automatic polarity, and overrange indication. You can depend upon the DM-700, state-of-the-art components such as a precision laser trimmed resistor array, semiconductor band gap reference, and reliable LSI circuitry insure lab quality performance for years to come. Basic DC volts and ohms accuracy is 0.1%, and you can measure voltage all the way from 100 μv to 1000 volts, current from 0.1 μa to 2.0 amps and resistance from 0.1 ohms to 20 megohms. Overload protection is inherent in the design of the DM-700, 1250 volts, AC or DC on all ranges, making it virtually goof proof. Power is supplied by four 'C' size cells, making the DM-700 portable, and, as options, a nicad battery pack and AC adapter are available. The DM-700 features a handsome, jet black, rugged ABS case with convenient retractable tilt bail. All factory wired units are covered by a one year limited warranty and kits have a 90 day parts warranty.

Order a DM-700, examine it for 10 days, and if you're not satisifed in every way, return it in original form for a prompt refund.

Specifications

DC and AC volts:	100 μV to 1000 Volts, 5 ranges
DC and AC current:	0.1 μA to 2.0 Amps, 5 ranges
Resistance:	0.1Ω to 20 megohms, 6 ranges
Input protection:	1250 volts AC/DC all ranges fuse protected for overcurrent
Input impedance:	10 megohms, DC/AC volts
Display:	3½ digits, 0.5 inch LED
Accuracy:	0.1% basic DC volts
Power:	4 'C' cells, optional nicad pack, or AC adapter
Size:	6"W x 3"H x 6"D
Weight:	2 lbs with batteries

Prices

DM-700 wired + tested	$99.95
DM-700 kit form	79.95
AC adapter/charger	4.95
Nicad pack with AC adapter/charger	19.95
Probe kit	3.95

TERMS: Satisfaction guaranteed or money refunded. COD, add $1.50. Minimum order $6.00. Orders under $10.00, add $.75. Add 5% for postage, insurance, handling. Overseas, add 15%. NY residents, add 7% tax.

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600 mHz COUNTER

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The CT-70 breaks the price barrier on lab quality frequency counters. No longer do you have to settle for a kit, half-kit or poor performance, the CT-70 is completely wired and tested, features professional quality construction and specifications, plus is covered by a one year warranty. Power for the CT-70 is provided by four 'AA' size batteries or 12 volts, AC or DC, available as options are a nicad battery pack, and AC adapter. Three selectable frequency ranges, each with its own pre-amp, enable you to make accurate measurements from less than 10 Hz to greater than 600 mHz. All switches are conveniently located on the front panel for ease of operation, and a single input jack eliminates the need to change cables as different ranges are selected. Accurate readings are insured by the use of a large 0.4 inch seven digit LED display, a 1.0 ppm TCXO time base and a handy LED gate light indicator.

The CT-70 is the answer to all your measurement needs, in the field, in the lab, or in the ham shack. Order yours today, examine it for 10 days, if you're not completely satisfied, return the unit for a prompt and courteous refund.

Specifications

Frequency range:	10 Hz to over 600 mHz
Sensitivity:	less than 25 mv to 150 mHz less than 150 mv to 600 mHz
Stability:	1.0 ppm, 20-40°C; 0.05 ppm/°C TCXO crystal time base
Display:	7 digits, LED, 0.4 inch height
Input protection:	50 VAC to 60 mHz, 10 VAC to 600 mHz
Input impedance:	1 megohm, 6 and 60 mHz ranges 50 ohms, 600 mHz range
Power:	4 'AA' cells, 12 V AC/DC
Gate:	0.1 sec and 1.0 sec LED gate light
Decimal point:	Automatic, all ranges
Size:	5"W x 1½"H x 5½"D
Weight:	1 lb with batteries

Prices

CT-70 wired + tested	$99.95
CT-70 kit form	75.95
AC adapter	4.95
Nicad pack with AC adapter/charger	14.95
Telescopic whip antenna, BNC plug	7.95
Tilt bail assembly	3.95

ramsey electronics

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More Details? CHECK — OFF Page 110

KENWOOD

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...for the discerning Amateur who demands quality.

R-820/TS-820S

SP-820 R-820 TS-820S

TS-820S

The TS-820S is a very popular 160-10 meter SSB/CW/RTTY transceiver, preferred by DX operators and other particular Amateurs. It employs a single-conversion PLL circuit.

TS-820S FEATURES:

- 200 W PEP SSB/160 W DC CW/100 W DC FSK input on 160-10 meters.
- Digital frequency display, with backup monoscale analog dial.
- IF shift (receiver passband tuning) to eliminate interference.
- RF speech processor.
- Effective noise blanker.

OPTIONAL ACCESSORIES:

- CW-820 (YG-88C) 500-Hz CW filter.
- DS-1A DC-DC converter.
- AT-200 antenna tuner.

R-820

The R-820 is a highly sophisticated HF receiver for the Amateur who wants the highest quality with the most operating features. A combination of the R-820 and TS-820S provides the ultimate HF operating system.

R-820 FEATURES:

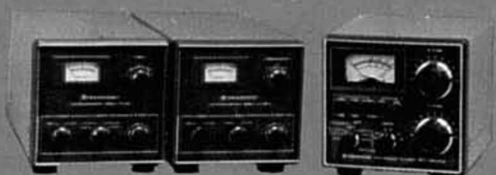
- Full transceive operation with TS-820S, providing full frequency control with either unit.
- Covers 160-10 meters, as well as WWV (15.0-15.5 MHz), and four shortwave broadcast bands (49, 31, 25, and 16 meters).
- Receives SSB, CW, AM, and RTTY modes.
- Double-tuned RF stages and improved dynamic range.
- IF shift (passband tuning).
- Variable bandwidth tuning (VBT).
- Very sharp, deep notch circuit... in 50-kHz IF.
- Provisions for extra-sharp 455-kHz IF filters.
- Noise-blanker with variable threshold level.
- Digital frequency display, with backup analog dial.

OPTIONAL ACCESSORIES:

- YG-88C 500-Hz CW filter, for first IF.
- YG-88A 6-kHz AM filter, for first IF.
- YG-455C 500-Hz filter, for second IF.
- YG-455CN 250-Hz filter, for second IF.

SP-820 TS-820S VFO-820

ACCESSORIES FOR TS-820 AND TS-520 SERIES



TV-502S TV-506 AT-200
(not for TS-520SE)

AT-200 antenna tuner handles 200 W, 160-10 meters.
TV-502S 2-meter transverter covers 144-146 MHz. (Not intended for TS-520SE.)
TV-506 6-meter transverter covers 50-54 MHz. (Not intended for TS-520SE.)

TL-922A

The TL-922A linear amplifier for all Kenwood HF equipment provides maximum legal power on the 160-15 meter Amateur bands, employing a pair of EIMAC 3-500Z high-performance transmitting tubes.

TL-922A FEATURES:

- 2000 W PEP (SSB)/1000 W DC (CW, RTTY) input power on 160-15 meters, with 80 W drive.
- Excellent IMD characteristics.
- Safety protection.
- Blower with automatic delay circuit.
- Variable threshold level type ALC.

SM-220

The SM-220 Station Monitor is capable of various monitoring functions, and performs as a wideband oscilloscope, and is expandable for pan-display operation.

SM-220 FEATURES:

- Monitors transmitted SSB and CW waveforms from 1.8 to 150 MHz.
- High-sensitivity, wide-frequency-range (up to 10 MHz) oscilloscope.
- Monitors received signals in IF stage.
- Tests linearity of linear amplifiers (provides trapezoid pattern).
- Allows observation of RTTY tuning points (cross pattern).
- Built-in two-tone (1000-Hz and 1575-Hz) generator.
- Expandable to pan-display capability for observing the number and amplitude of stations within a switchable ±20 kHz/±100 kHz bandwidth.

OPTIONAL ACCESSORIES:

- BS-8 pan-display module for TS-180S and TS-820 series.
- BS-5 pan-display module for TS-520 series.

KENWOOD

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...for the discerning Amateur who demands quality.

TS-120S

(MC-35S MIKE OPTIONAL)

Truly a "big little rig," the TS-120S has created a new excitement in HF communications for highly versatile Amateur operation. The compact, all solid-state 80-10 meter transceiver, with up to 200 watts PEP input, requires no tuning and includes a large digital readout, making it ideal for mobile operation. IF shift and other important features make it a high-quality rig for the ham shack as well.

TS-120S FEATURES:

- All solid-state with wideband amplifier stages. No final dipping or loading, no transmit drive peaking, and no receive preselector tuning.
- Transceives on 80 through all of 10 meters, and receives WWV on 15 MHz.
- 200 W PEP/160 W DC input on 160-15 meters, and 160 W PEP/140 W DC on 10 meters. LSB, USB, and CW.
- Digital frequency display (standard) shows actual frequency. Backup analog subdial also included.
- IF shift (passband tuning) to eliminate QRM.
- Advanced PLL circuit, with improved stability and spurious characteristics on transmit and receive.
- Effective noise blanker.
- Built-in cooling fan, which activates automatically when final-amplifier heatsink temperature rises to 90° C.
- Protection circuit for final transistors.
- VOX.

OPTIONAL ACCESSORIES:

- YK-88CW 500-Hz filter.
- MB-100 mobile mount.

PS-30 SP-120 TS-120S VFO-120 MC-50

AT-120

AT-120 antenna tuner with mobile mounting bracket included. Features SWR meter and matches 50-ohm input to 20-300 ohms unbalanced output. Handles 150 watts (120 watts on 80 meters).

TS-520SE

SP-520 TS-520SE W/DG-5 VFO-520S

The TS-520SE is an economical version of the TS-520S...the world's most popular 160-10 meter Amateur transceiver. Now, any Amateur can afford a high-quality HF transceiver for his ham shack.

TS-520SE FEATURES:

- Covers 160-10 meters and receives WWV on 15 MHz.
- 200 W PEP input on SSB and 160 W DC on CW.
- CW WIDE/NARROW bandwidth switch, for use with the optional CW-520 500-Hz CW filter.
- Digital display with optional DG-5, showing actual frequency.
- Speech processor, effective in DX pileups.
- VOX and semi-break-in CW with sidetone.
- Built-in 25-kHz calibrator.

OPTIONAL ACCESSORIES:

- CW-520 500-Hz CW filter.
- AT-200 antenna tuner.

The TS-520S is still available, with DC (mobile) operating capability (with the optional DS-1A DC-DC converter) and transverter terminals, which were eliminated from the TS-520SE.

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expanded memory for the Autek MK-1 programmable keyer

Additional 2120AL RAM chips and switching logic allow memory capacity increase

Many on-the-air contacts confirm the popularity of the Autek Research MK-1 memory keyer. It's a superb performer and not too expensive. Recently a good friend, Mr. Meyer Minchen (AG5G), asked for my help in expanding the memory capability of his MK-1. What follows is a description of a simple and inexpensive addition to the keyer that can increase its memory capacity by as little or as much as desired.

The heart of the MK-1 memory is the versatile 2102 random-access memory (RAM) chip. It's capable of storing up to 1024 bits of data and comes in a 16-pin, dual-inline package. One very important feature of this chip is its TRI-STATE™ outputs, which allow any number of 2102s to be paralleled as long as only one memory is enabled at a time. The logic state of pin 13 determines whether the chip is active. By switch selecting one — and only one — chip at a time, the total memory capacity can be increased to virtually any amount.

construction

Fig. 1 shows how simple this system actually is. In AG5G's case, five additional 2102s were added to the original memory for a total capacity of 6144 bits, a substantial increase.

AG5G's method of constructing the memory is unique and bears serious consideration by those interested in this modification. The original 2102 (Q12 on the Autek schematic) was removed and replaced with a 16-pin DIP header purchased from the local Radio Shack store (part 276-1980). A single 2102 was soldered to the exposed pins of the DIP header with the exception of pin 13 (the chip enable pin), which was bent out at a right angle. A second 2102 was then soldered directly to the first chip, piggyback style, again with the exception of pin 13. This process was continued until the last chip had been soldered to the stack.

Be very careful not to allow one or more of the chips to be turned around during this part of the

By William B. Jones, N9AKT, 7224 Lakeshore Drive, Racine, Wisconsin 53402

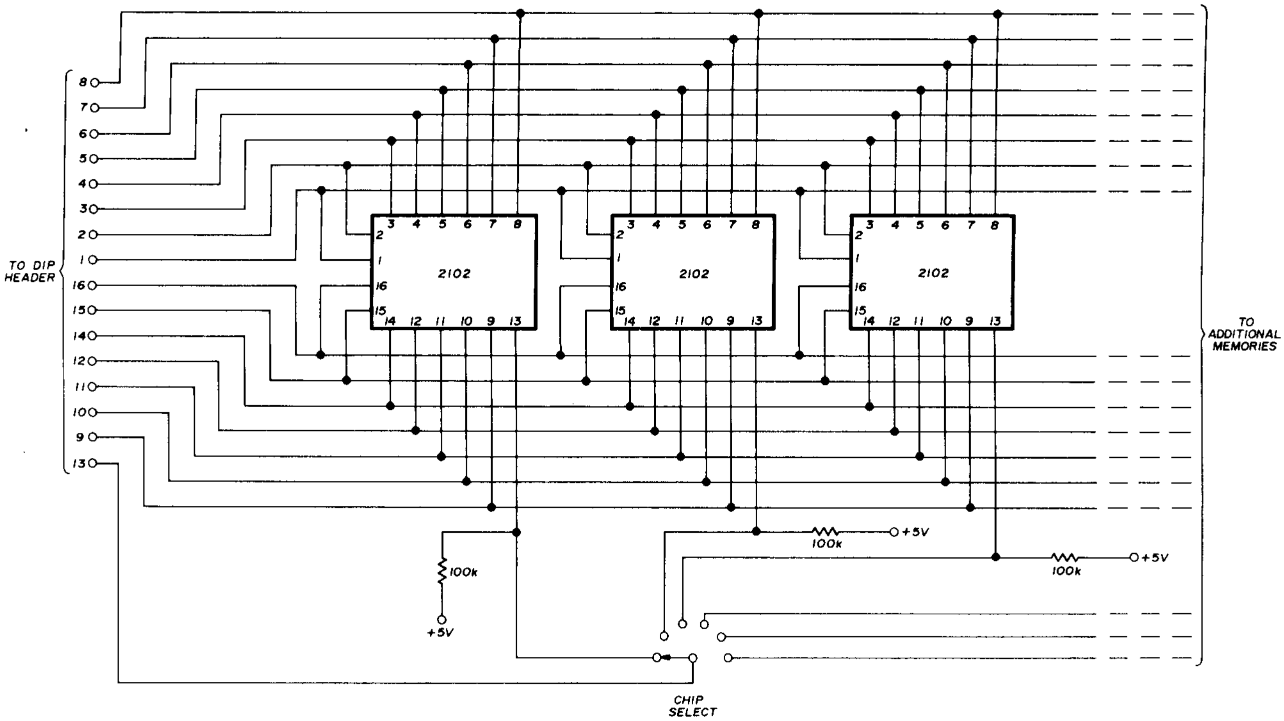

fig. 1. Expanded memory for the Autek MK-1 programmable keyer.

assembly. Use a low-wattage soldering iron, and make every effort not to get the chips too hot. A piece of ribbon cable or individual wires are then soldered from pins 13 to the rotary switch (Radio Shack 275-1386) as shown in **fig. 1**. In addition, a 100k resistor is soldered from each pin 13 to +5 Vdc, which disables the chip when not being used. Finally, a single wire is soldered from the common terminal of the rotary switch to pin 13 of the DIP header. AG5G says that there's more than enough space on the keyer front panel to mount the rotary switch.

Although five of the six memory chips are always disabled, the information stored in them is not lost or altered in any way. Normal operation of the MK-1 is not changed by this modification. There are still four separate message areas per chip. Messages C and D may still be combined at will; it's just that now you can switch between any of the desired chips, each one operating independently of the others.

power considerations

Anyone contemplating this modification to the MK-1 keyer should be aware that the built-in power supply was designed to operate the keyer and *one* memory chip. The supply isn't capable of supplying the current that five more 2102s require. AG5G solved this problem by substituting a Radio Shack 2-amp transformer (part 273-1512) for the existing unit. He mounted the transformer on the inside of the cover and used small in-line cable connectors as disconnects to facilitate separation of case and cover.

In addition, he replaced the 1N5231B 5.1-volt zener and its 100-ohm current-limiting resistor (D15 and R32 respectively) with a three-terminal, 5-volt regulator similar to the 7805 because he thought that the zener might not handle the additional current demands. The 7805 is also available at your local Radio Shack store and the cost is under two dollars. With minimal heat-sinking the regulator runs very cool, as it's required to supply less than 100 mA when using six low-power versions of the 2102 (2102-AL).

comments from AG5G

The cost of doubling the memory capacity of the unit by adding only one memory (2102-AL) chip and a mini SPDT toggle switch is less than $4.00. My experiments indicate that the memory capacity can be doubled within the present transformer capability by adding only one 2102-AL piggyback, following the procedure covered in this article, and using a mini SPDT toggle switch in place of the 6-position rotary switch.

The cost of adding five 2102-AL chips, the 6-position switch, transformer, and voltage regulator (7805) with heatsink is less than $15.00. I used six 2102-AL chips, replacing the higher-current 2102 chip that was in the unit.

The time required for doubling the memory is less than one hour. It takes less than three hours to install the transformer, voltage regulator (7805), six chips, and switch.

It's important to note, from my experiments and tests, that all memory functions and capabilities of the MK-1 are multiplied by the number of 2102-AL chips added without any impairment of the operations of the unit, provided *the voltage is regulated and current is amply supplied.*

In building my stack of six chips piggyback, I left about 1.5 mm (1/16 inch) between each chip as I added them vertically. (I don't think the space I left for cooling is necessary.) The transformer mounted easily, centered inside the top of the cabinet with ample space remaining to clear other parts when the top was replaced on the unit. With the unit's original transformer removed, there's some space available for mounting other items.

After installing the transformer to meet the increased requirements for current, to ensure better voltage regulation I removed the output of the two diodes (D12 and D13) from the board, joined their output together as input to a 7812 voltage regulator, and wired the output of the 7812 to where I had removed the output of D12 and D13. (The transformer that came in the unit could not handle the current requirements of the six 2102-AL chips but could meet the requirement for current for one additional 2102-AL.)

A 24-36 VCT transformer with 500-600 mA capacity will handle the requirements of the unit after adding six 2102-AL chips. The total (maximum) current requirements of the MK-1 as measured (after installing the transformer, 7812 and 7805 voltage regulators, and six 2102-AL chips) between the output of the 7812 and the load was 225 mA.

I believe that, thanks to N9AKT's creativity, this has been the easiest, lowest cost, most beneficial and rewarding project I've built in the past forty years. It substantially increases the capability and versatility of the MK-1 and makes this already excellent piece of Amateur Radio equipment even more useful.

closing notes

The simplicity of this project definitely puts it in the "weekend" category. Both the casual operator and the contester should benefit from the added memory capacity this modification affords. It's expandable one step at a time, as desired, and, best of all, it won't strain the family budget. Try it and see how much easier operating can be with an expanded memory for the Autek MK-1 programmable keyer.

ham radio

More Details? CHECK—OFF Page 110

observations on the speed of light through the metric system

A look at the phase velocity of EM waves in nonionized atmosphere and space

Upsetting apple carts is not the way to treat the fruits of one's labor, and I'm becoming very disturbed with people who are trying to destroy my faith in the metric system of units. After all, why should I use an EM wave phase velocity of 186,363.6 miles per second when I can use a nice even 3.0 x 10^8 meters per second?

background

Some inconsiderate person came along and concluded that this phase velocity should be 186,300 miles per second, which is about 2.998766 x 10^8 meters per second. Upon further examination it was discovered that this wasn't right either. It was concluded that the phase velocity should be 186,287 miles per second, which is about 2.998756 x 10^8 meters per second.

In 1953, Kraus got us back into the right (?) units.[1] But he concluded that this phase velocity is 2.998 x 10^8 meters per second, which is about 186,239.39 miles per second. (Rounded off, it's 186,240 mps. Take your choice.)

Then in 1962 Corson and Lorraine concluded that this phase velocity should be 2.9979 x 10^8 meters per second,[2] which is about 186,233.18 miles per second. It appears that they were either lazy or sloppy in their work, or else they were victims of round-off errors.

In 1970, the ITT staff concluded that this phase velocity should be 2.99793 x 10^8 meters per second,[3] which is about 186,235.05 miles per second, give or take a few mm. Then, less than a year ago, I saw somewhere that this phase velocity should be 2.997925 x 10^8 meters per second, which is about 186,234.73 miles per second.

Now, authorities agree that this velocity should be 2.99792456 x 10^8 meters per second,[4] which is about 186,234.71 miles per second.

In analyzing these data, I could conclude that the last twenty years of observations have shown that the EM wave phase velocity decreases at rate of about

$$V_d \approx \frac{1}{3.0(1.284)^{yr}} \text{ miles/second/year}$$

On this basis we would eventually arrive at an EM wave phase velocity of about 186,234.40 miles per second, or about 2.99791961 x 10^8 meters per second. Since neither of these figures are neat round numbers, I now wonder if those in EM-wave work should develop a new set of units, which are not related to a British King or the size of the earth. Meanwhile, if I want to stay with the MKS system of units on a *current* basis, the above observations suggest that I should reconcile my wishes and reality and round off the EM wave phase velocity to 2.99792 x 10^8 meters per second.

At the same time, I question the phase velocity of 299,792,456 meters per second given by the "authorities" cited in reference 4. First, what decimal fractional part was rounded off to the whole number of 6? Second, is the EM wave velocity in space or is it near a mass — the same as that in an atmosphere? I doubt it, and we'll have to be patient until better answers are forthcoming.

Since these observations were noted, I've read somewhere that this phase velocity is now 186,000 miles per second, or about 2.99338 x 10^8 meters per second. This is very disturbing because it suggests that we'll not be able to propagate EM waves at all by the 21,000th century, and everything propagated beforehand will be returning to us thereafter.

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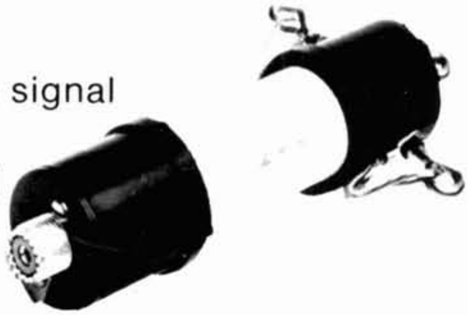

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More Details? CHECK — OFF Page 110

log-periodic antennas
for the high-frequency Amateur bands

Design data for
two LP wire beams:
one for 10, 15, and 20 meters,
and one for
future ham bands
in the 10-30 MHz region

***In a recent article*[1] W6PYK** illustrated the design of a log periodic (LP) antenna covering the 10-, 15-, and 20-meter Amateur bands using a simplified approach. The antenna design parameters were $\tau = 0.875$ (the taper factor) and $\sigma = 0.13$ (the spacing factor). This design provides a ten-element LP with a boom length of 15.6 meters (51 feet) and a gain of 6.7 dB over a dipole. All element lengths and element spacing dimensions were provided for those wishing to build a good three-band fixed-wire beam with a fair amount of gain.

measurement accuracy

You'll note that W6PYK[1] rounds off the values for element lengths and spacing distances. Some authors describing LP-antenna designs for Amateurs often show these measurements with decimals to the fourth, fifth, or even sixth place! Probably many Amateurs have been discouraged after seeing this amount of measurement precision. No doubt some of this showmanship is to impress the reader that the author has access to a computer. But as Paul, W6PYK, says, "The LP is very forgiving of construction and design tolerances." I've found this to be true in my LP antenna designs.

Over the past eight years I've assembled and tested more than thirty high-frequency LP antennas for various frequency ranges and gains including monobanders and two- and three-banders. Using a four-function calculator, lengths and spacings can be shown to four or five decimal places, but I always round off to no more than *two* places for ease in measuring, usually converting the measurements to feet and inches (meters and centimeters) for the lower-frequency bands and certainly no closer than 6 mm (0.25 inch) for the higher-frequency bands, which is plenty close.

By George E. Smith, W4AEO, in collaboration with **Paul A. Scholz, W6PYK**. Mr. Smith's address is 1816 Brevard Place, Camden, South Carolina 29020. Mr. Scholz's address is 12731 Jimeno Avenue, Granada Hills, California 91344

calculation example

Let's run through some LP design calculations using W6PYK's data (reference 1). We'll use his **table 1** and antenna 3 ($B = 2$), with fourteen elements and $\ell/\lambda = 1.37$.

table 1. 14-element LP designed to $\tau = 0.917$ and $\sigma = 0.17$. $\ell/\lambda = 1.37$; *gain* = 8 *dBd*.

	length			spacing distance	
element	meters	(feet)		meters	(feet)
1	10.0	(33.4)	S1	3.7	(12.0)
2	9.4	(30.7)	S2	3.4	(11.0)
3	8.5	(28.0)	S3	3.0	(10.0)
4	7.9	(25.8)	S4	2.8	(9.2)
5	7.2	(23.6)	S5	2.6	(8.5)
6	6.6	(21.7)	S6	2.4	(7.8)
7	6.0	(19.9)	S7	2.2	(7.1)
8	5.6	(18.2)	S8	2.0	(6.5)
9	5.1	(16.7)	S9	1.8	(6.0)
10	4.7	(15.3)	S10	1.6	(5.4)
11	4.3	(14.0)	S11	1.5	(5.0)
12	3.9	(12.9)	S12	1.4	(4.6)
13	3.6	(11.8)	S13	1.3	(4.2)
14	3.3	(10.8)	total:	29.7	(97.3)

Since we start with 14 MHz as our low-end cutoff frequency, f_L, the free-space wavelength, λ_0, will equal 984/14 or 21.4 meters (70.3 feet). The boom length will be 29 meters (94.9 feet). If these dimensions aren't too large for the available space, we proceed as follows:

1. As our $f_L = 14\ MHz$, the length of the E1 rear element will be $468/14 = 10$ *meters (33.4 feet)*. Under the τ column of the table note that $\tau = 0.917$ and $\sigma = 0.17$. These parameters determine the taper factor, τ, and spacing factor, σ, for the remaining calculations.

2. Next we calculate the spacing distance between E1 and E2. $S1 = \sigma \times \lambda_0 = 0.17 \times 70.3 = 11.96$ *feet.* Make it 3.7 meters (12 feet).

3. Next we calculate the other element lengths, E2, E3 . . . En, where En is the *nth* element. From **step 1** $E1 = 10$ *meters (33.4 feet).* $E2 = E1 \times \tau = 9.4$ *meters (30.7 feet).* The remaining element lengths are calculated similarly.

4. The remaining spacing distance, S2, S3 . . . Sn are calculated thus: $S2 = S1 \times \tau = 3.3$ *meters (11 feet).* $S3 = S2 \times \tau = 3$ *meters (10 feet)* and so on for S4 . . . Sn.

design aid

For those who don't wish to compute an LP using W6PYK's easy design method, complete dimensions are given in **tables 1** and **2** for two 14-29-MHz LPs for 20, 15, and 10 meters.

about cost

Some hams with whom I've discussed LPs feel that the LP requires quite a bit of wire for the number of bands covered, especially one covering a 2:1 ($B = 2$) frequency range (one octave). This is true for a large LP covering 80 and 40 or even 40 and 20 meters; however, since an LP covering 14-29 MHz includes three bands (20, 15, and 10) you get more for the money. My antenna for these bands cost about $35.00 to $50.00 for wire, nylon line, and lucite insulators (coax, baluns, and towers not included). For these reasons I feel that LPs for 80 or 40 meters should be limited to a monoband LP ($B = 1$) since the range between 4.0 and 7.0 MHz or 7.3 and 14 MHz isn't needed.

The least expensive, or rather the most "cost effective," LPs built here have been those designed for 14-21.5 MHz ($B = 1.5$) for 20 and 15 meters only. The first LP put up here was a seven-element array with a boom length of 11 meters (37.5 feet). It was described in reference 2.

table 2. 19-element LP designed to $\tau = 0.943$ and $\sigma = 0.175$. $\ell/\lambda = 1.97$; *gain* = 8.9 *dBd*.

	length			spacing distance	
element	meters	(feet)		meters	(feet)
1	10.0	(33.4)	S1	3.7	(12.3)
2	9.6	(31.5)	S2	3.5	(11.6)
3	9.1	(29.7)	S3	3.3	(10.9)
4	8.5	([illegible])	S4	3.1	(10.3)
5	8.1	(26.4)	S5	3.0	(9.7)
6	7.6	(24.9)	S6	2.8	(9.2)
7	7.2	(23.5)	S7	2.7	(8.7)
8	6.8	(22.2)	S8	2.5	(8.2)
9	6.4	(20.9)	S9	2.3	(7.7)
10	6.0	(19.7)	S10	2.2	(7.3)
11	5.7	(18.6)	S11	2.1	(6.8)
12	5.3	(17.5)	S12	2.0	(6.5)
13	5.0	(16.5)	S13	1.9	(6.1)
14	4.8	(15.6)	S14	1.7	(5.7)
15	4.5	(14.7)	S15	1.6	(5.4)
16	4.2	(13.9)	S16	1.5	(5.1)
17	4.0	(13.1)	S17	1.4	(4.8)
18	3.7	(12.2)	S18	1.3	(4.5)
19	3.5	(11.6)	total:	43.0	(140.8)

Fig. 1 is a drawing of the 14-29-MHz LP suggested by W6PYK for 20, 15, and 10 meters with an array length of 15.6 meters (51 feet). Note how the three cells for 20, 15, and 10 meters overlap in a fairly short (array length) LP. All elements are used (no waste of wire), as compared with an LP for 80 and 40 or 40 and 20 meters.

a 10-30 MHz-LP for future Amateur bands

An LP designed to cover 10-30 MHz may be of future interest, as W6PYK mentioned in his article.[1] Hopefully, we'll be awarded the proposed ham

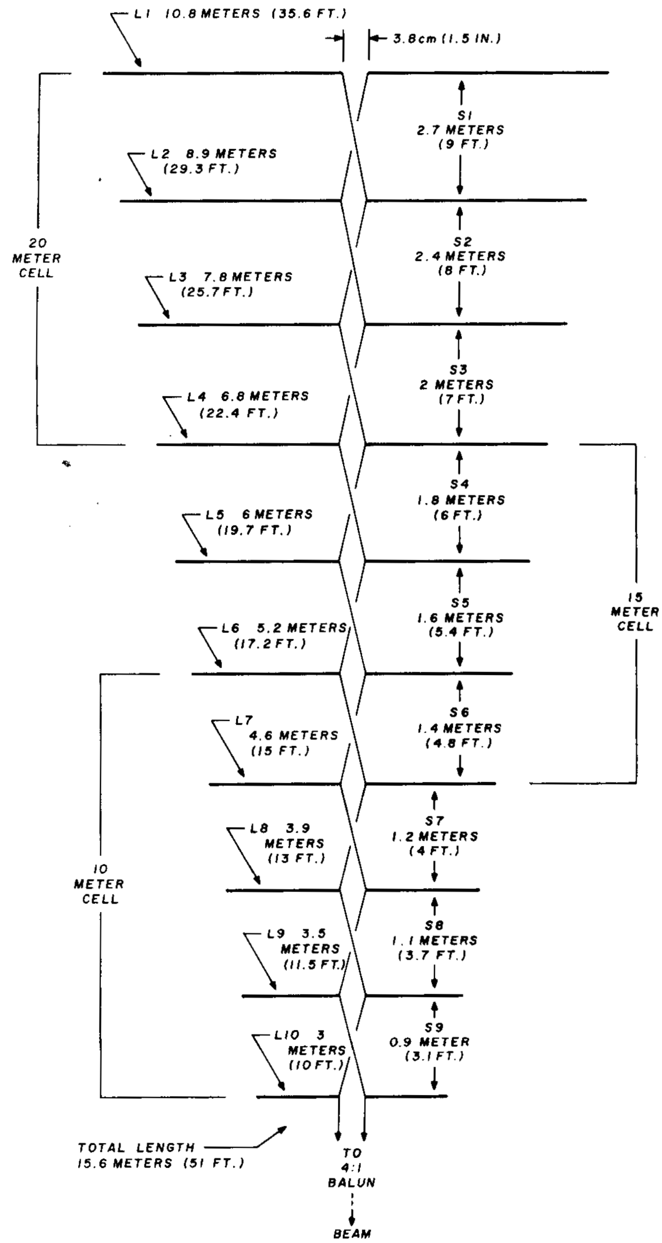


fig. 1. Ten-element 14-29-MHz log periodic antenna for 10, 15, and 20 meters. Designed to τ = 0.875 and δ = 0.13. Gain = 6.7 dBd. Note how the three "cells" for 10, 15, and 20 meters overlap — no waste of wire.

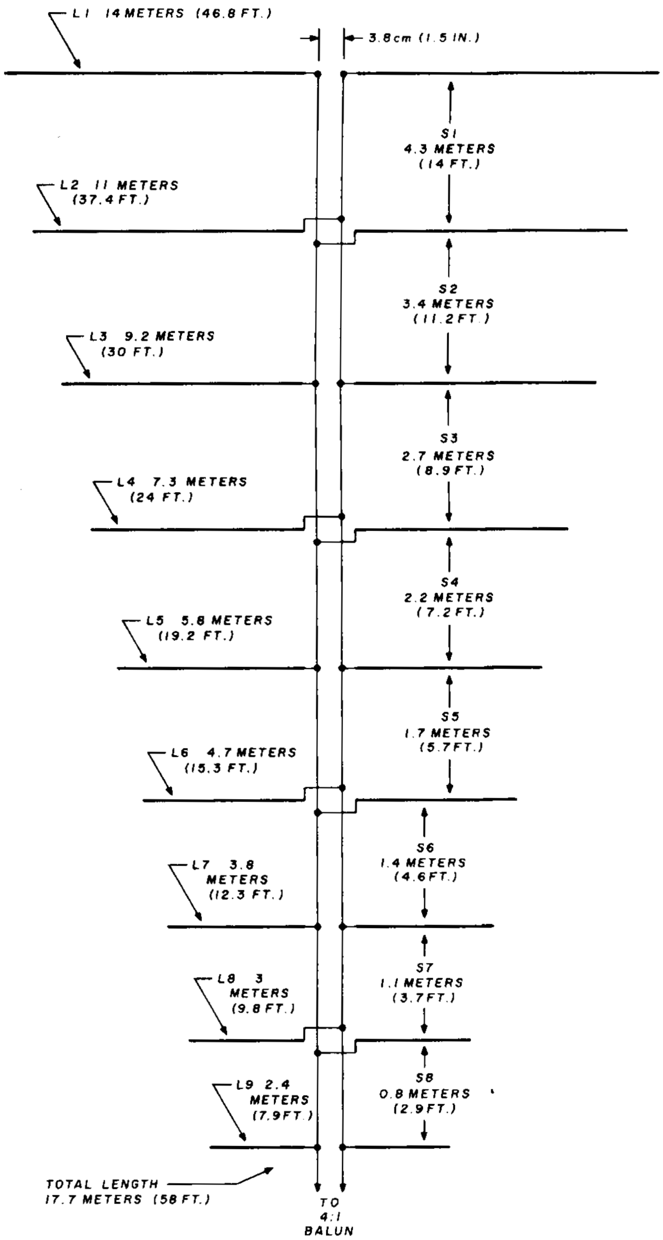


fig. 2. Nine-element LP designed for 10-30 MHz, using τ = 0.80 and δ = 0.142. Gain = 5.9 dBd. This will cover future Amateur bands as proposed in the WARC conference in Geneva.

bands: 10.1, 18.1, and 25.25 MHz at the forthcoming WARC Geneva conference. An LP designed to cover the entire 10-30-MHz spectrum will then be usable on six bands: 10.1, 14, 18.1, 21, 25.25 and 28 MHz.

As Paul states it would be difficult, and quite a mechanical challenge, to design a practical six-band rotatable Yagi similar to the present triband Yagis.

Fig. 2 shows dimensions for a nine-element ($B = 3$) 10-30 MHz LP designed to $\tau = 0.8$ and $\sigma = 0.142$, which gives an array length of 17.7 meters (58 feet) and a 5.9-dBd gain. Although this is a moderate gain, it's probably about as good as some of the present tribanders and about as good as can be expected from an LP with such a short boom length. A big advantage is that gain and SWR are relatively constant over the entire range of 10-30 MHz. A further advantage is that it covers our present 14-, 21-, and 28-MHz bands plus the proposed 10.1-, 18.1-, and 25.5-MHz bands.

references

1. Paul A. Scholz, W6PYK, "Another Approach to Log-Periodic Antenna Design," *ham radio*, December, 1979, page 34.
2. George E. Smith, W4AEO, "Log Periodic Beam for 15 and 20 Meters," *ham radio*, May, 1974, page 6.

ham radio

7400 TTL

SN7400N	.16	SN7470N	.29	SN74160N	.89
SN7401N	.18	SN7472N	.29	SN74161N	.89
SN7402N	.18	SN7473N	.35	SN74162N	1.95
SN7403N	.18	SN7474N	.35	SN74163N	.89
SN7404N	.18	SN7475N	.49	SN74164N	.89
SN7405N	.20	SN7476N	.35	SN74165N	.89
SN7406N	.29	SN7479N	5.00	SN74166N	1.25
SN7407N	.29	SN7480N	.50	SN74167N	1.95
SN7408N	.20	SN7482N	.99	SN74170N	1.59
SN7409N	.20	SN7483N	.59	SN74172N	6.00
SN7410N	.18	SN7485N	.79	SN74173N	1.25
SN7411N	.25	SN7486N	.35	SN74174N	.89
SN7412N	.25	SN7489N	1.75	SN74175N	.79
SN7413N	.40	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.59	SN74177N	.79
SN7416N	.25	SN7492N	.43	SN74179N	1.95
SN7417N	.25	SN7493N	.43	SN74180N	.79
SN7420N	.20	SN7494N	.65	SN74181N	1.95
SN7421N	.29	SN7495N	.65	SN74182N	.79
SN7422N	.39	SN7496N	.65	SN74184N	1.95
SN7423N	.25	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	.89	SN74186N	9.95
SN7426N	.29	SN74107N	.35	SN74188N	3.95
SN7427N	.25	SN74109N	.59	SN74190N	1.25
SN7429N	.39	SN74116N	1.95	SN74191N	1.25
SN7430N	.20	SN74121N	.35	SN74192N	.79
SN7432N	.25	SN74122N	.39	SN74193N	.79
SN7437N	.25	SN74123N	.49	SN74194N	.89
SN7438N	.25	SN74125N	.49	SN74195N	.69
SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
SN7442N	.49	SN74141N	.79	SN74199N	1.49
SN7443N	.75	SN74142N	2.95	SN74S200	4.95
SN7444N	.75	SN74143N	2.95	SN74251N	.99
SN7445N	.75	SN74144N	2.95	SN74279N	.79
SN7446N	.69	SN74145N	.79	SN74283N	2.25
SN7447N	.59	SN74147N	1.95	SN74284N	3.95
SN7448N	.79	SN74148N	1.29	SN74285N	3.95
SN7450N	.20	SN74150N	.89	SN74365N	.69
SN7451N	.20	SN74151N	.59	SN74366N	.69
SN7453N	.20	SN74152N	.59	SN74367N	.69
SN7454N	.20	SN74153N	.59	SN74368N	.69
SN7459A	.25	SN74154N	.99	SN74390N	1.95
SN7460N	.20	SN74155N	.79	SN74393N	1.95
		SN74156N	.79		
		SN74157N	.65		

C/MOS

CD4000	.23	CD4028	.89	CD4070	.55
CD4001	.23	CD4029	1.19	CD4071	.23
CD4002	.23	CD4030	.49	CD4072	.49
CD4006	1.19	CD4035	.99	CD4076	1.39
CD4007	.25	CD4040	1.19	CD4081	.23
CD4009	.49	CD4041	1.25	CD4082	.23
CD4010	.49	CD4042	.99	CD4093	.99
CD4011	.23	CD4043	.89	CD4098	2.49
CD4012	.25	CD4044	.89	MC14409	14.95
CD4013	.39	CD4046	1.79	MC14410	14.95
CD4014	1.39	CD4047	2.50	MC14411	14.95
CD4015	1.19	CD4048	1.35	MC14419	4.95
CD4016	.49	CD4049	.49	MC14433	19.95
CD4017	1.19	CD4050	.49	MC14506	.75
CD4018	.99	CD4051	1.19	MC14507	.99
CD4019	.49	CD4053	1.19	MC14562	14.50
CD4020	1.19	CD4056	2.95	MC14583	3.50
CD4021	1.39	CD4059	9.95	CD4508	3.95
CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	.23	CD4066	.79	CD4511	1.29
CD4024	.79	CD4068	.39	CD4515	2.95
CD4025	.23	CD4069	.45	CD4518	1.29
CD4026	2.25			CD4520	1.29
CD4027	.69			CD4566	2.25

74C00

74C00	.39	74C85	2.49	74C163	2.49
74C02	.39	74C90	1.95	74C164	2.49
74C04	.39	74C93	1.95	74C173	2.60
74C08	.49	74C95	1.95	74C192	2.49
74C10	.39	74C107	1.25	74C193	2.49
74C14	1.95	74C151	2.90	74C195	2.49
74C20	.39	74C154	3.00	74C922	7.95
74C30	.39	74C157	2.15	74C923	6.25
74C42	1.95	74C160	2.49	74C925	8.95
74C48	2.49	74C161	2.49	74C926	8.95
74C73	.89			80C95	1.50
74C74	.89			80C97	1.50

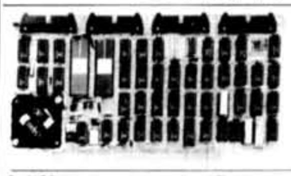
LINEAR

78MG	1.75	LM340K-18	1.35	LM710N	.79
LM106H	.99	LM340K-24	1.35	LM711N	.39
LM300H	.80	LM340T-5	1.25	LM723N/H	.55
LM301CN/H	.35	LM340T-6	1.25	LM733N	1.00
LM302H	.75	LM340T-8	1.25	LM739N	1.19
LM304H	1.00	LM340T-12	1.25	LM741CN/H	.35
LM305H	.60	LM340T-15	1.25	LM741-14N	.39
LM307CN/H	.35	LM340T-18	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-24	1.25	LM748N/H	.39
LM309H	1.10	LM358N	1.00	LM1310N	1.95
LM309K	1.25	LM370N	1.95	LM1458CN/H	.59
LM310CN	1.15	LM373N	3.25	MC1488N	1.95
LM311N/H	.90	LM377N	4.00	MC1489N	1.95
LM312H	1.95	LM380N	1.25	LM1496N	.95
LM317K	6.50	LM380CN	.99	LM1556V	1.75
LM318CN/H	1.50	LM381N	1.79	MC1741SCP	3.00
LM319N	1.30	LM382N	1.79	LM2111N	1.95
LM320K-5	1.35	NE501N	8.00	LM2901N	2.95
LM320K-5.2	1.35	NE510A	6.00	LM3053N	1.50
LM320K-12	1.35	NE529A	4.95	LM3065N	1.49
LM320K-15	1.35	NE531H/V	3.95	LM3900N(3401)	.59
LM320K-18	1.35	NE536T	6.00	LM3905N	1.49
LM320K-24	1.35	NE540L	6.00	LM3909N	1.25
LM320T-5	1.25	NE544N	4.95	MC5558V	.59
LM320T-5.2	1.25	NE550N	1.30	8038B	4.95
LM320T-8	1.25	NE555V	.39	LM75450N	.49
LM320T-12	1.25	NE556N	.99	75451CN	.39
LM320T-15	1.25	NE560B	5.00	75452CN	.39
LM320T-18	1.25	NE561B	5.00	75453CN	.39
LM320T-24	1.25	NE562B	5.00	75454CN	.39
LM323K-5	5.95	NE565N/H	1.25	75491CN	.79
LM324N	1.49	NE566CN	1.75	75492CN	.89
LM339N	.99	NE567V/H	.99	75493N	.89
LM340K-5	1.35	NE570N	4.95	75494CN	.89
LM340K-6	1.35	LM703CN/H	.69	RC4136	1.25
LM340K-8	1.35	LM709N/H	.29	RC4151	3.95
LM340K-12	1.35			RC4194	4.95
LM340K-15	1.35			RC4195	4.49

74LS00TTL

74LS00	.29	74LS47	.89	74LS138	.89
74LS01	.29	74LS51	.29	74LS139	.89
74LS02	.29	74LS54	.29	74LS151	.89
74LS03	.29	74LS55	.29	74LS155	.89
74LS04	.35	74LS73	.45	74LS157	.89
74LS05	.35	74LS74	.45	74LS160	1.15
74LS08	.29	74LS75	.59	74LS161	1.15
74LS09	.35	74LS76	.45	74LS162	1.25
74LS10	.29	74LS78	.49	74LS163	1.15
74LS11	.35	74LS83	.89	74LS164	1.25
74LS13	.59	74LS85	1.25	74LS175	.99
74LS14	1.25	74LS86	.45	74LS181	2.49
74LS15	.35	74LS90	.59	74LS190	1.15
74LS20	.29	74LS92	.75	74LS191	1.15
74LS21	.35	74LS93	.75	74LS192	1.15
74LS22	.35	74LS95	.99	74LS193	1.15
74LS26	.35	74LS96	1.15	74LS194	1.15
74LS27	.35	74LS107	.45	74LS195	1.15
74LS28	.35	74LS109	.45	74LS253	.99
74LS30	.29	74LS112	.45	74LS257	.89
74LS32	.35	74LS123	1.25	74LS258	1.75
74LS37	.45	74LS125	.89	74LS260	.69
74LS40	.35	74LS132	.99	74LS279	.75
74LS42	.89	74LS136	.49	74LS367	.75
				74LS368	.75
				74LS670	2.49

Cromemco
incorporated



TU-ART Digital Interface

Cromemco's TU-ART digital interface is a convenient interface for CRT terminals, line printers, modems, and other devices. Has 2 serial I/O ports, 2 8-bit parallel I/O ports, and 10 independent programmable interval timers. Baud rates are software-selectable from 110-76,800 baud. Has vectored prioritized interrupts so it is able to support the powerful vectored interrupt structure of a Z-80 microprocessor. 10 interval timers w/real-time capability.

Serial I/O Ports: No. of ports: 2; I/O levels: RS 232 or 20mA curr. loop; Low baud range: 110-9600 baud (software selectable); High baud range: 880-76,800 baud (software selectable). **Parallel I/O Ports:** No. of ports: 2; Input ports: 8 bits; Output ports: 8 bits; Input load: one TTL equivalent; Output Drive: 20 TTL loads

Interval Timers: No. of timers: 10; Timer range: 0-16.32 msec (software selectable); Timer resolution: 64 microseconds. **Vectored Interrupts:** No. restart locations (8080 model): 8; No. restart locs. (Z-80 model): 65,536; Prioritization of TU-ART ports: internally prioritized; Prioritization for multiple TU-ARTs: daisy chaining

General Information: UART Type: 5501; Bus: S-100; Power requirements: +8V @ 1.0A, +18V @ 80mA, -18V @ 40mA; Operating environment: 0-55°C

TRT-W (Assembled) $295.00

DISCRETE LEDS

.200" dia.			.125" dia.		
XC556R	red	5/$1	XC209R	red	5/$1
XC556G	green	4/$1	XC209G	green	4/$1
XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
.200" dia.			.185" dia.		
XC22R	red	5/$1	XC526R	red	5/$1
XC22G	green	4/$1	XC526G	green	4/$1
XC22Y	yellow	4/$1	XC526Y	yellow	4/$1
.170" dia.			XC526C	clear	4/$1
MV10B	red	4/$1	.190" dia.		
.085" dia.			XC111R	red	5/$1
MV50	red	6/$1	XC111G	green	4/$1
			XC111Y	yellow	4/$1
			XC111C	clear	4/$1

INFRA-RED LED
1/4"x1/4"x1/16" flat
5/$1

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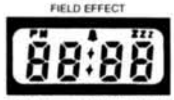
LIQUID CRYSTAL DISPLAY CLASS II
FIELD EFFECT



4 DIGIT — .5" CHARACTERS
THREE ENUNCIATORS
2.00" X 1.20" PACKAGE
INCLUDES CONNECTOR

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T1001A-Reflective	8.25

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MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.49	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.49	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	1.50
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character, (± 1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA3023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

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DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg C.A. LED driver	1.50

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MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
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MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	.16	.15	22 pin LP	$ .37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100		1-24	25-49	50-100
14 pin ST	$.27	.25	.24	28 pin ST	$ .99	.90	.81
16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
24 pin ST	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin SG	$.30	.27	.24	24 pin SG	$ .70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin WW	$.39	.38	.31	22 pin WW	$ .95	.85	.75
10 pin WW	.45	.41	.37	24 pin WW	1.05	.95	.85
14 pin WW	.39	.38	.37	28 pin WW	1.40	1.25	1.10
16 pin WW	.43	.42	.41	36 pin WW	1.59	1.45	1.30
18 pin WW	.75	.68	.62	40 pin WW	1.75	1.55	1.40
20 pin WW	.85	.79	.72				

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1N746	3.3	400m	4/1.00	1N4004	400 PIV 1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV 1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV 1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV 1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50 200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75 10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35 10m	12/1.00
1N959	8.2	400m	4/1.00	1N4733	5.1 1w	.28
1N965	15	400m	4/1.00	1N4734	5.6 1w	.28
1N5232	5.6	500m	.28	1N4735	6.2 1w	.28
1N5234	6.2	500m	.28	1N4736	6.8 1w	.28
1N5235	6.8	500m	.28	1N4738	8.2 1w	.28
1N5236	7.5	500m	.28	1N4742	12 1w	.28
1N5242	12	500m	.28	1N4744	15 1w	.28
1N5245	15	500m	.28	1N1183	50 PIV 35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV 35 AMP	1.70
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TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369A	4/1.00	MPS3705	5/1.00	2N5087	4/1.00
MPS2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2484	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2906	4/1.00	2N3707	5/1.00	2N5129	5/1.00
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47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

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.22/35V	.28	.23	.17	3.3/25V	.35	.31	.27
.33/35V	.28	.23	.17	4.7/25V	.33	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.49	.45	.35
.68/35V	.28	.23	.17	15/25V	.75	.68	.59
1.0/35V	.28	.23	.17	22/6V	.75	.60	.50

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1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

More Details? CHECK—OFF Page 110

FIRST OF A SERIES

FTC Revolt

You've heard of the tax revolt. It's about time for an FTC revolt. Here's my story and why we've got to stop federal bureaucratic regulation.

My story is only one example of how the FTC is harassing small businesses but I'm not going to sit back and take it.

By Joseph Sugarman, W9IQO
President, JS&A Group, Inc.

I'm pretty lucky. When I started my business in my basement eight years ago, I had little more than an idea and a product.

The product was the pocket calculator. The idea was to sell it through advertisements in national magazines and newspapers.

Those first years in the basement weren't easy. But, we worked hard and through imaginative advertising and a dedicated staff, JS&A grew rapidly to become well recognized as an innovator in electronics and marketing.

THREE BLIZZARDS

In January of 1979, three major blizzards struck the Chicago area. The heaviest snowfall hit Northbrook, our village—just 20 miles north of Chicago.

Many of our employees were stranded—unable to get to our office where huge drifts made travel impossible. Not only were we unable to reach our office, but our computer totally broke down leaving us in even deeper trouble.

But we fought back. Our staff worked around the clock and on weekends. First, we processed orders manually. We also hired a group of computer specialists, rented outside computer time, employed a computer service bureau, and hired temporary help to feed this new computer network. We never gave up. Our totally dedicated staff and the patience of many of our customers helped us through the worst few months in our history. Although there were many customers who had to wait over 30 days for their parcels, every package was eventually shipped.

WE OPENED OUR DOORS

During this period, some of our customers called the FTC (Federal Trade Commission) to complain. We couldn't blame them. Despite our efforts to manually notify our customers of our delays, our computer was not functioning making the task extremely difficult.

The FTC advised JS&A of these complaints. To assure the FTC that we were a responsible company, we invited them to visit us. During their visit we showed them our computerized microfilm system which we use to back up every transaction. We showed them our new dual computer system (our main system and a backup system in case our main system ever failed again). And, we demonstrated how we were able to locate and trace every order. We were very cooperative, allowing them to look at every document they requested.

The FTC left. About one week later, they called and told us that they wanted us to pay a $100,000 penalty for not shipping our products within their 30-day rule. (The FTC rule states that anyone paying by check is entitled to receive their purchase within 30 days or they must be notified and given the option to cancel.)

NOT BY CONGRESS

The FTC rule is not a law nor a statute passed by Congress, but rather a rule created by the FTC to strengthen their enforcement powers. I always felt that the rule was intended to be used against companies that purposely took advantage of the consumer. Instead, it appears that the real violators, who often are too difficult to prosecute, get away while JS&A, a visible and highly respected company that pays taxes and has contributed to our free enterprise system, is singled out. I don't think that was the intent of the rule.

And when the FTC goes to court, they have the full resources of the US Government. Small, legitimate businesses haven't got a chance.

We're not perfect. We do make mistakes. But if we do make a mistake, we admit it, accept the responsibility, and then take whatever measures necessary to correct it. That's how we've built our reputation.

BLOW YOUR KNEE CAPS OFF

Our attorneys advised us to settle. As one attorney said, "It's like a bully pulling out a gun and saying, 'If you don't give me a nickle, I'll blow your knee caps off.'" They advised us that the government will subpoena thousands of documents to harass us and cause us great inconvenience. They warned us that even if we went to court and won, we would end up spending more in legal fees than if we settled.

To settle would mean to negotiate a fine and sign a consent decree. The FTC would then issue a press release publicizing their victory.

At first we tried to settle. We met with two young FTC attorneys and agreed in principle to pay consumers for any damages caused them. But there were practically no damages, just a temporary computer problem, some late shipments, and some bad weather. The FTC then issued a massive subpoena requesting documents that will take us months to gather and which we feel was designed to harass or force us to accept their original $100,000 settlement request.

Remember, the FTC publicizes their actions. And the higher the fine, the more the publicity and the more stature these two attorneys will have at the FTC.

If this all sounds like blackmail—that's just what it appeared to be to us.

We did ship our products late—something we've admitted to them and which we publicly admit here, but we refuse to be blackmailed into paying a huge fine at the expense of our company's reputation—something we've worked hard eight years to build.

We're not a big company and we realize it would be easier to settle now at any cost. But we're not. If this advertisement can attract the attention of Congressmen and Senators who have the power to stop the harassment of Americans by the FTC, then our efforts will be well spent.

ALL AMERICANS AFFECTED

Federal regulation and the whims of a few career-building bureaucrats is costing taxpayers millions, destroying our free enterprise system, affecting our productivity as a nation and as a result is lowering everybody's standard of living.

I urge Congressmen, Senators, businessmen and above all, the consumer to support legislation to take the powers of the FTC from the hands of a few unelected officials and bring them back to Congress and the people.

I will be running this advertisement in hundreds of magazines and newspapers during the coming months. I'm not asking for contributions to support my effort as this is my battle, but I do urge you to send this advertisement to your Congressmen and Senators. That's how you can help.

America was built on the free enterprise system. Today, the FTC is undermining this system. Freedom is not something that can be taken for granted and you often must fight for what you believe. I'm prepared to lead that fight. Please help me.

Note: To find out the complete story and for a guide on what action you can take, write me personally for my free booklet, "Blow your knee caps off."

JS&A PRODUCTS THAT THINK®
One JS&A Plaza, Northbrook, Ill. 60062

communications audio processor for reception

This article describes a system aimed at the special needs of Amateur Radio CW and voice signal reception. It's called the Comm Audio processor (CAP) and uses a combination of special voice-frequency filters, binaural synthesis, Tone-Tag modulation, and controlled antiphasic noise.

design considerations

Much attention was given to aspects of human engineering, signal environment, and operation in the CAP design. For example, most ham receivers provide plenty of band spread and a high-quality, calibrated tuning control, so selecting frequency in an add-on unit would be redundant. Accordingly, the CAP has been designed so that once everything is set up for a given voice or CW mode, most attention and operational control remains within your basic receiver. Aside from human engineering aspects, our very complex signal environment — both manmade and natural — contributed to the system design. In this respect the FCC's frequency allocation system heavily influenced all of the hardware because, through their regulation, there are at least three major radio signal environments in the high frequency spectrum: First, clear-channel frequencies are available for many industrial, public-broadcast, and governmental activities. Second, there are channelized frequency blocks, such as CB and many commercial and government allocations. Finally there is our type. We hams are required to fit our signals into frequency *bands* but aren't regimented into *channels* (so a few freedoms do remain!).

Because we have freedom of choice on any frequency within an allocated band, we're able to get five to ten times more useful communications functions in the ham phone bands than can be obtained in FCC channelized allocations of equal bandwidth, and up to fifty times or more in the CW bands. Certainly this signal density is such that QRM is one of the Q codes most popular; but the pressure has resulted, and will continue to result, in transmitter, receiver, antenna, and control design improvements. Clearly, our signal environment demands that we do not transmit on or receive unnecessary frequencies.

In addition to the human engineering and signal

environmental aspects, there is the belief on my part that most hams, particularly DXers, are interested in enhancing weak-signal reception when there are strong signals nearby. The key to this is retaining an awareness of the noise floor and maintaining linearity in the signal path throughout an entire receiving system. A strong signal will suppress a weak signal either through the use of agc or by allowing compression of any stage. CAP was designed in consideration of these objectives.

In the system shown in **fig. 1**,* design effort has been directed toward an audio system for the Amateur brand of voice and CW communications. The unit contains the following key features, none of which are found to a refined degree in manufactured receivers:

1. Voice-shaped filter — thirteen poles to improve signal-to-noise ratio and reduce QRM by rejecting a broad spectrum between the first and second voice formants.

2. Binaural synthesis for both voice and CW.

3. Tone-Tag — the system that distinctively modulates any signal tuned to 750 ± 50 Hz, the binaural crossover frequency.

4. Nine-pole, 100-Hz bandwidth, stagger-tuned filter for super-steep skirts with a passive prefilter.

5. A continuously adjustable pink (soft) noise source — the how and why of this is covered in detail.

By Don E. Hildreth, W6NRW, Hildreth Engineering, P.O. Box 60003, Sunnyvale, California 94088

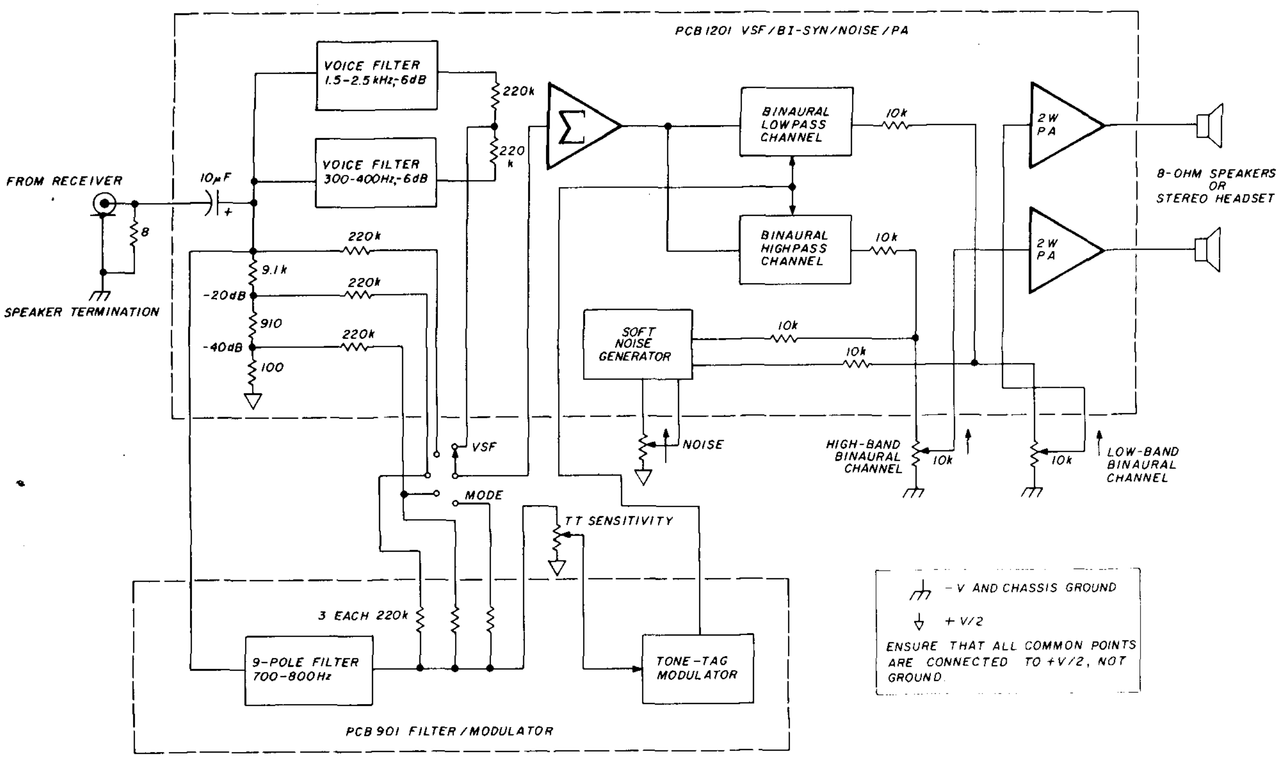


fig. 1. Comm Audio Processor.

Over the years many voice-manipulating systems have been proposed and developed, all aimed at making more effective use of the actual spectral distribution in the human voice. Most recently Dr. Richard W. Harris and J. F. Cleveland developed an excellent technique.[1] In this system, the voice spectrum is transformed following your transmitter's microphone output, as shown in **fig. 2.** The second and third voice formants (contained in the dashed area) are folded by a 3.1-kHz oscillator, mixer, and filters, which results in a band between about 300 and 1600 Hz for transmission.

An inverse system, again using a 3.1-kHz oscillator, mixer, and filters at the received audio end, unfolds (returns) second and third formants to their proper position (dashed). The amount of bandwidth actually involved is not reduced but merely rearranged.

Although frequency tolerances will have to be tightened, this system can nearly double the effective spectrum now used for voice-only, channelized communications. Since it can be applied to services such as CB, police, fire, and many other industrial, commercial, and governmental functions, frequency companding of this type could reduce the pressures to gobble up the ham bands.

*A drilled and etched PC-board set is available for $9.95 postpaid. Send a self-addressed, stamped envelope for a complete product listing to Hildreth Engineering, P.O. Box 6003, Sunnyvale, California 94088. Phone (408) 245-3279.

The Comm Audio Processor design is based on the reality that those working in ham frequency bands up to 28 MHz are involved in nonchannelized communications, which is also heavily influenced by skip conditions.

We play billiards with the ionosphere, which reduces the effectivity of a frequency compandor. If you can't tell, because of skip, where other stations may be, how do you know where to place your bundles of voice energy?

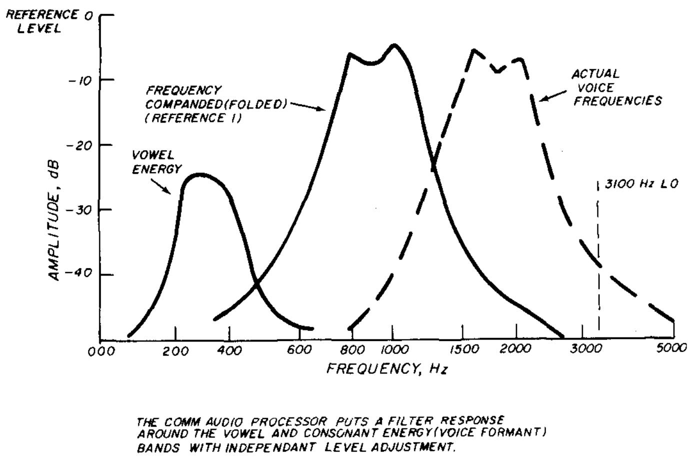


fig. 2. Folded voice-spectrum on approximated energy distribution. The Comm Audio Processor puts a filter response around the vowel and consonant energy (voice formant) bands with independent level adjustment.

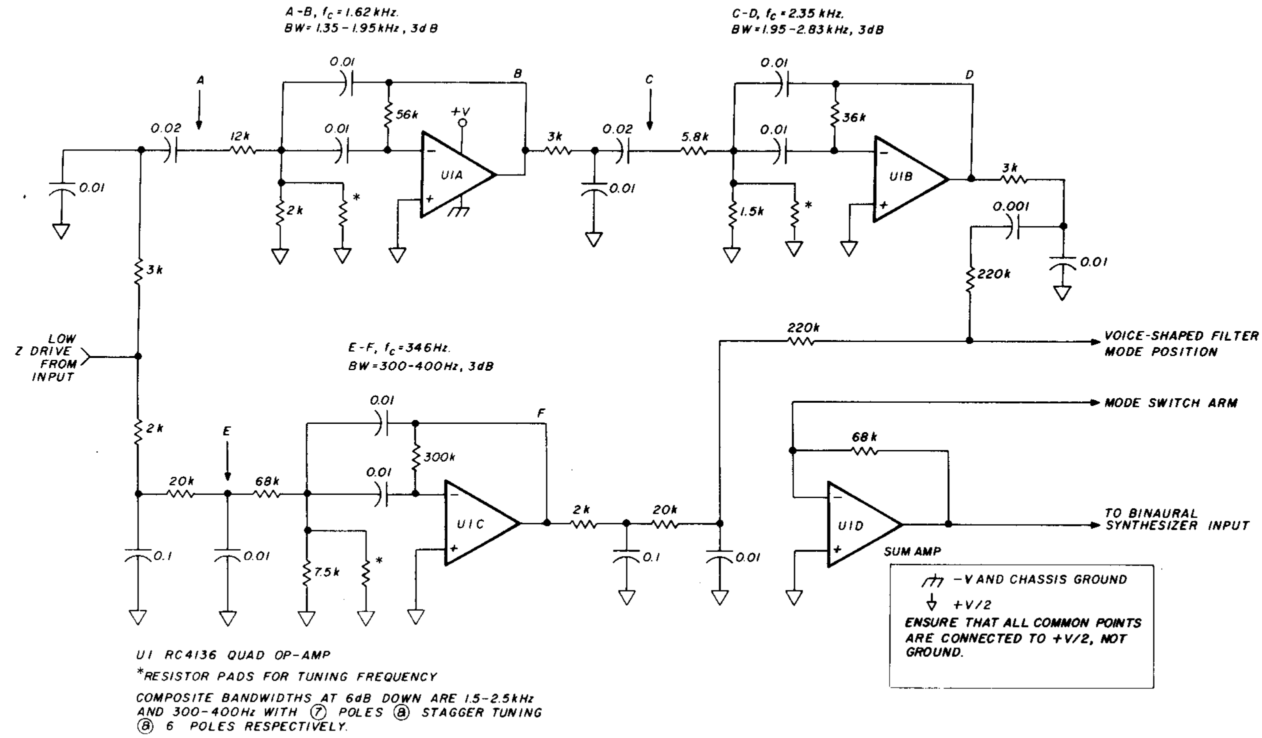


fig. 3. Voice-shaped filter and sum amplifier. Composite bandwidths at 6-dB down are 1.5-2.5 kHz and 300-400 Hz with seven poles and stagger tuning and six poles respectively.

Fig. 3 shows CAP's voice-shaped filter (VSF). In this case, it's not mandatory to roll transmitted voice energy off sharply above 2.5 kHz. It is desirable, however, because 2.5 kHz of bandwidth (or, more accurately, response from 1.5 to 2.5 kHz) will supply the basic needs for voice communications; the human voice does emit unnecessary energy to 10 kHz or so. Even though this energy can be filtered at the receiving end by someone listening to *you*, this energy will appear as lower frequencies — thus unfilterable — for other stations up to 8 or 9 kHz away. The design shown in **fig. 3** can also be used in your microphone circuit. It would make other hams in our crowded bands very happy.

binaural synthesizer

To synthesize a binaural sound environment, the audio output passband from any receiver is divided (with reasonably sharp filters) into two parts. Frequencies below 750 Hz are fed to one speaker and frequencies above 750 Hz are fed to another. The speakers are located as you would place them for stereo listening. Speaker locations and their resulting stereo amplitude potentials are shown in **fig. 4**. A maximum differential of 7 dB (only slightly more than one S unit of signal strength) holds through most of a typical voice communications bandwidth from about 500 Hz to 3 kHz.[2] Below 500 Hz the human stereo potential diminishes; below 300 Hz it's gone.

Since the 7-dB differential occurs because of the "sound shadow" presented by your head, you may leap to the thought of a huge improvement by using stereo headsets. But wait. It won't happen. You can get a better amplitude differential with headsets, but that's not the whole story. Our brain processes a sound wave, or many, in terms of much more than

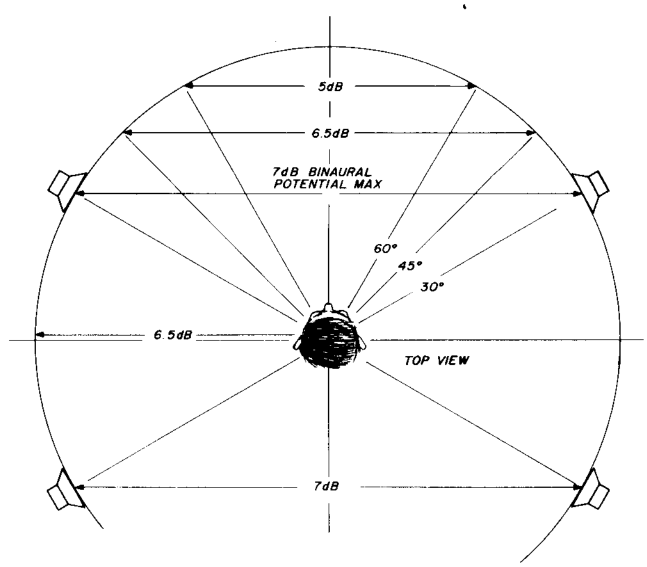


fig. 4. Locating speakers for best binaural amplitude separation. The maximum effective binaural differential based on intensity is obtained when speakers are located forward of, or behind, an imaginary line through your ears by about 30 degrees.

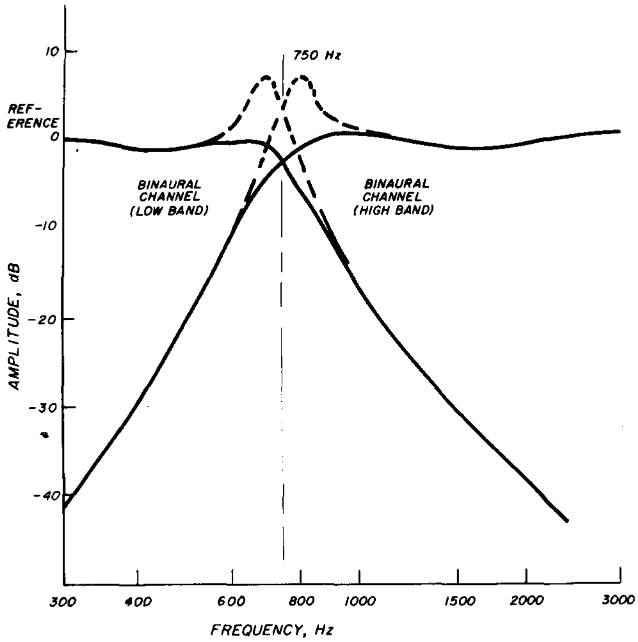


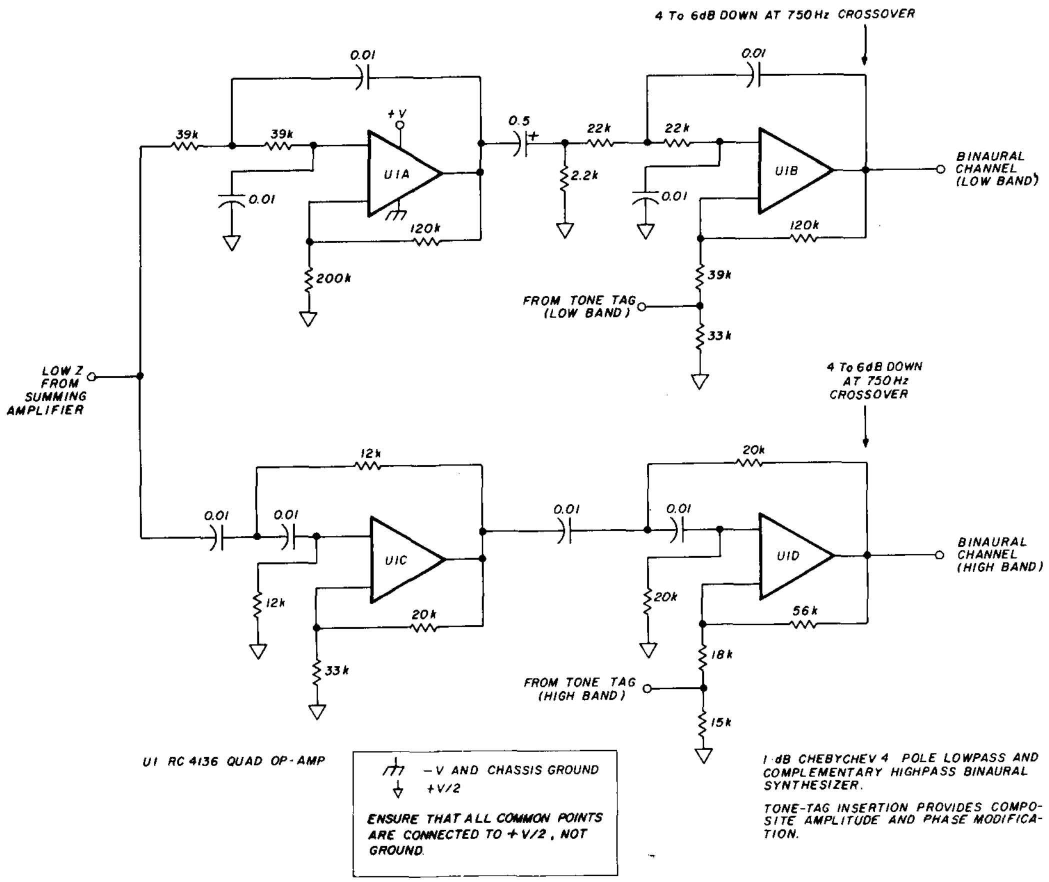
fig. 5 (above). Binaural response. Solid lines show approximate 1-dB Chebychev response. Tone-Tag changes response to dashed lines 100 times/second.

fig. 6 (below). 1-dB Chebychev four-pole lowpass and complementary highpass binaural synthesizer. Tone-Tag insertion provides composite amplitude and phase modulation.

just relative amplitude. There are also time-of-arrival and phase variation phenomena. Headsets wipe these out in our system. When using speakers with the binaural synthesis method used here, sounds originate to the right or left in space, just as in nature. However, when a CW beat note is tuned to the crossover frequency of 750 Hz, the brain gets equal information in terms of amplitude and time-of-arrival from both left and right azimuths, resulting in the impression of "surround sound." Headsets work well, of course, but you just won't get the improvement you may expect.

In the CAP, 1-dB Chebychev four-pole lowpass and complementary highpass filters are used, with a frequency crossover (equal energy from both sides) at 750 Hz. The voltage control voltage source (VCVS) active filter form enables the insertion of Tone-Tag modulation. **Fig. 5** shows a representative response (solid lines). Tone-Tag modulation alternates the response between the solid and dashed lines, but only as driven by a signal tuned to 750 ±50 Hz through a 9-pole filter and at a nominal 100-Hz rate. **Fig. 6** is a complete schematic.

In the first article describing a binaural synthesizer for CW reception[3] a simple cascade of 2-pole filters was used. To improve the crossover slope without adding more poles and to improve Tone-Tag inser-



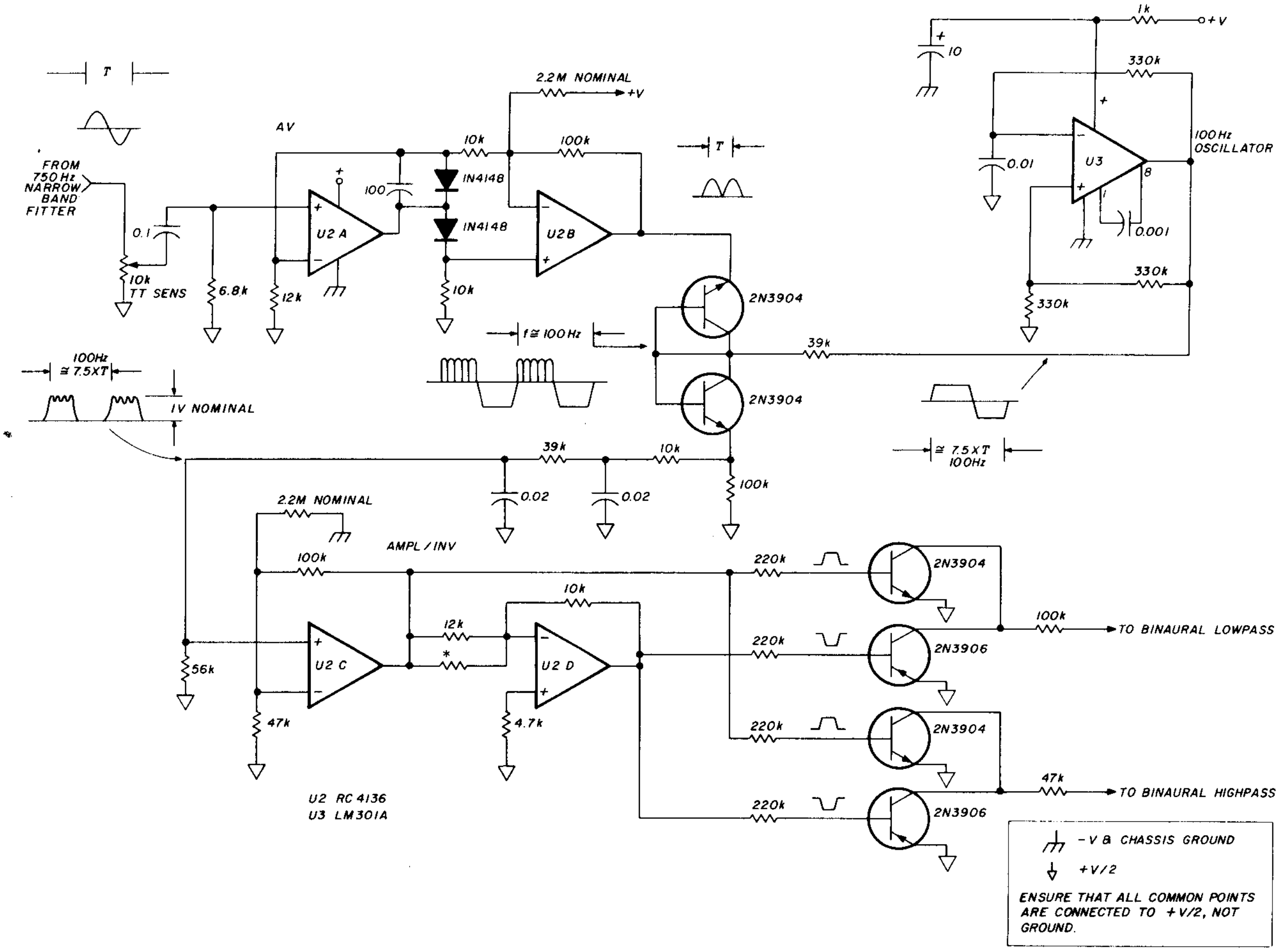


fig. 7. Tone-Tag modulator. Resistor marked with an asterisk at U2D — input is adjusted for minimum tone output from the binaural lowpass when at least 100 mW of 750 Hz signal is at the input above and the signal input line of the binaural section is grounded to signal ground (V/2). Resistor nominal value is 57k.

tion, the design has been changed to the Chebychev type. (Burr-Brown[4] supplies an excellent set of tables for Butterworth, Bessel, and Chebychev designs.) To improve antiphasic response enabled by the binaural system, the low- and high-pass systems are adjusted to be about 4-6 dB down at the 750-Hz crossover frequency.

Tone-Tag

The Tone-Tag system first used (model 1100) was based on simplicity.[5] Now, however, refinement has set in. Our model 1500 changed the modulator from diodes to a balanced bipolar technique to improve weak-signal performance in a noisy background. And CAP adds still further, although minor, improvement. **Fig. 7** shows the heart of our current Tone-Tag modulator design.

The absolute value (AV) circuit — also called a precision rectifier — transforms any incoming signal to a 750 ±50 Hz rectified, unfiltered positive output with a gain of ten. When no signal is present, positive excursions of a nominal 100-Hz oscillator are clamped to a nominal +0.5 volt by a diode-connected transistor working against the low-impedance zero output of the AV op-amp. A second diode-connected transistor, turned around, subtracts most of the +0.5 volt signal and rejects the negative half cycles of the 100-Hz oscillator signal. When an input signal appears, positive excursions appear at the AV output, and the diode-connected transistor releases its clamp on the 100-Hz oscillator, which results in the waveforms shown.

Since more current normally flows in the first diode than in the second, the second diode voltage doesn't quite offset that of the first. The resistor from − of U2B to +V provides a small compensating offset at the U2B output, resulting in a near zero voltage at U2C input.

When no 750-Hz signal is present, U2C provides a nominal gain and a small offset, which sets the modulator transistors to near conduction. U2D inverts U2C output to provide a balanced drive to the com-

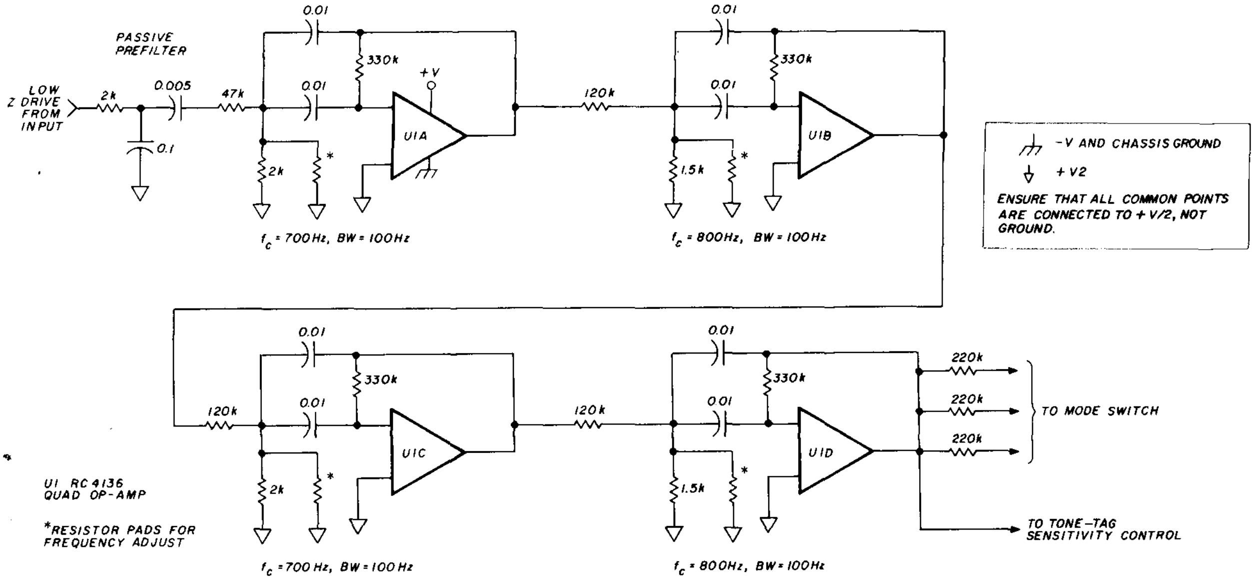


fig. 8. Nine-pole, 100-Hz bandwidth stagger-tuned, 750-Hz filter. Passive prefilter provides pole at 750 Hz with phase-corrective element.

plementary modulator transistor switches. This action is precisely set with the padding resistor marked with an asterisk in **fig. 7**. Resistor-buffered switch outputs are fed to the binaural synthesizer (**fig. 6**).

9-pole narrowband filter

A narrowband filter centered at 750 Hz, the binaural crossover frequency, is required to drive the Tone-Tag AV input circuit. Since a filter of this type is popular in its own right, a very steep-skirted, stagger-tuned device was used. A passive prefilter is used in addition to quality RC4136 op-amps to mitigate the effects of transient intermodulation distortion that may be induced by impulse noise or transients (key clicks). The design also minimizes small-signal compression by strong nearby signals acting on the first, and most susceptible, filter stage. The composite is the 9-pole filter shown in **fig. 8**.

good noise — bad noise

White noise or pink noise (shaped) is often added to communications circuits to mask distracting forms of low-level interference. In most of its applications, this form of noise is soft and fluffy, even pleasant. Pink noise generators are even found in such diverse applications as sleep aids and pain suppressors for some dental operations. When properly used, this is "good" noise.

Then there's that other kind, the abrasive, or "bad," noise that ranges between 10 and 40 dB thick depending on frequency, time of day or year, and your location[6] (**fig. 9**). This noise, available at your antenna terminals, is the sum of many sources. Added to nature's atmospheric electrical disturbances, manmade electrical perturbations mix in to generate the din. Electrical circuits being made or broken create impulse-like radiation that chirps through the spectrum. Auto ignition, power leak . . . the list can go on and on.

Thermal noise — and, to a large extent, galactic noise — can be thought of as a statistical average of a very large number of low-energy electrical perturbations. At the same time, manmade and atmospheric noise comes from a much smaller number of relatively high-energy events. When heard, these noise types influence our receivers and our nervous systems very differently. The sum of the two noise

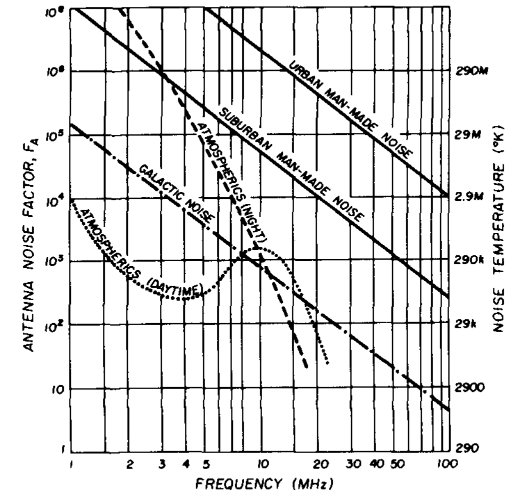


fig. 9. Receiver sensitivity is limited by the external available noise power, which varies with frequency. For a quiet, rural location, galactic noise is the limiting factor down to about 18 MHz, and atmospheric noise dominates below 18 MHz.

types could be described as a foam mattress (thermal noise) perforated by a family of random spikes (impulse noise and signals).

In practice, something approximating "good" noise may be heard by simply removing the antenna from your receiver and listening with an audio bandwidth of 2-3 kHz or more. The other stuff is what you hear when your antenna is reconnected and you tune with high gain to a spot where no signals are present (it's assumed your receiver is not noise-figure limited). Now, with antenna-received noise present, connect your receiver output to one of those ubiquitous multipole active audio filters. With the rf gain "up," you'll hear that tinkling roar that drives so many of us to look for a better solution, for, even though the little devices do a good job in some respects, they can't filter those noise components that sound like a signal itself. In addition, sporadic, impulse-like noise tweeks the filter to produce sounds approximating what you get if you rapidly strum the strings of a violin while damping them with the other hand. It doesn't ring long, to be sure, but the sounds produced are much too like the code structures in a weak CW signal.

listening experiments

In the Tone-Tag system first published[5], I made an attempt to get most of the benefits of a multipole narrow-band filter without listening "through" it. However to use Tone-Tag under high-sensitivity levels, coincidental to feeding the binaural synthesizer signal input port with the output of a narrowband filter (not the original intent), I found that the filter tinkling sound along with the desired signal was modulated — thus boosted — by Tone-Tag. Although the level was not too high, it was objectionable.

On a monaural basis I decided to try adding soft noise to mask those elements of noise that appear at a narrow-band filter output with the desired signal. The resulting signal sounded reasonably smooth; but weak signals suffered slightly under the noise load. The next step was to add the soft noise in-phase to binaural audio channels while the signal plus residual filter noise irritants were fed to the two channels in phase opposition, or approximately so.

It's well known that copying a signal in noise with a binaural antiphasic noise combination has a 15-20 dB advantage over the monaural case,[7] but the question was this: If a weak signal can be clearly heard when added to white noise in this way, will the signal's filtered residual noise components be masked by the white noise? Results were much better than expected!

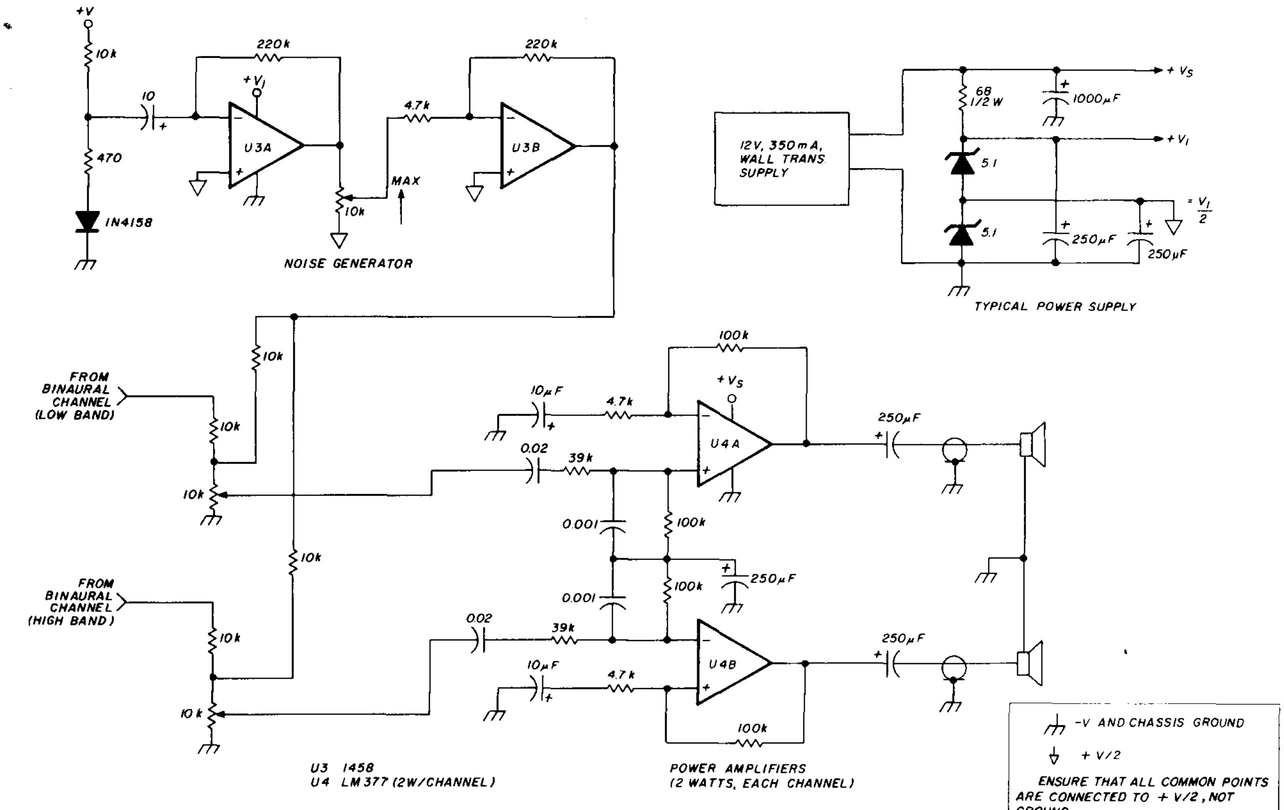


fig. 10. Noise source and audio power amplifiers.

I've spent many hours listening to compare the readability of a weak signal with or without soft noise added. Clearly it's more pleasing to listen to a signal plus soft noise, and that was expected. But readability, in many cases, was *improved*, which was not expected to the degree I found. Actually, I'd hoped to minimize signal readability degradation with the addition of antiphasic binaural noise. It now appears that when a weak signal and abrasive (impulse) noise pass through a narrowband filter, noise elements are transformed into sounds that are so much like the signal's coded structure that they compete with it. The result is a less readable signal. But with noise added in the right way and amount, readability is actually improved.

In no case during these listening tests could I detect signals with the white noise added that could not be detected without the added noise. As expected there was no basic improvement in signal-to-noise ratio. But a signal could often be copied with the added noise where it could be heard but not copied when the noise was removed. To date I've found no case where the addition of soft noise has made a signal less readable than without it. Clearly, of course, added noise has usually been at a level just necessary to mask the undesirable noise elements coming out of a narrowband filter. Happily, added noise benefits the critical application of the Tone-Tag referred to above as well!

Since the existing binaural synthesizer already supplies the desired antiphasic* condition, summing in-phase noise at the power-amplifier input adds very little to the cost in the CAP design — and one more control knob. **Fig. 10** shows the noise generator and how it's added at the junction of the binaural synthesizer and power amplifiers. Although most emphasis has been on the judicious addition of soft noise in CW reception, the feature can also be used to some advantage in the reception of voice signals.

operating with CAP

The main mode control switch enables the selection of the shaped-voice filter, a nominal 2.5-kHz flat bandwidth for either voice or CW or three CW filter positions. Any selected mode is fed into the binaural synthesizer filters. **Fig. 11** illustrates. Independent power output controls are provided for each binaural synthesizer channel, which allows compensation for different speaker or headset efficiencies or for special effects. The two remaining controls include Tone-Tag sensitivity and amplitude control for the soft-noise source.

When the voice-shaped filter is selected, tuning your SSB receiver will be easier — more like tuning an a-m signal than when the usual 2.5-kHz flat bandpass filter is used. When the frequency band from about 400-1500 Hz is deeply rejected, a slight-to-moderately mistuned station will not produce much output energy in this band, thus it more quickly disappears as you tune. In addition, under critical conditions often found on 14 MHz, for example, the binaural low-band from 300-400 Hz may be reduced to or near zero with the independent channel output control. Under this condition, the 300-400 Hz low-band segment is still available at approximately 30 dB down in the high-band binaural channel along with its normal 1.5-2.5 kHz response. The noise bandwidth in this super-sharp condition is only about 1 kHz. Clearly recognizable voice is available although it will be nearly devoid of character. Bringing *up* the binaural low-band control will progressively enable individual signal recognition. Some signal conditions allow boosting the low and reducing highs for 100-Hz bandwidth. One click on the mode control and you have the prevalent 2.5-kHz nominal, flat-voice bandwidth, but in binaural.

The 2.5-kHz binaural position is also useful for CW in general listening. When Tone-Tag is used with this bandwidth, the modulation effect is mild because of competition with a relatively wide noise bandwidth. But it's still adequate to provide excellent selectivity through the significant tone quality difference relative to other signals in the bandwidth. In addition, of course, signals not in the modulated pass-band appear on the right or left specifically, while the tagged signal is heard in "surround sound."

On the next click of the mode control, everything in the 2.5-kHz bandwidth — *except* the 100-Hz band centered at 750 Hz — drops 20 dB. All basic conditions remain the same as above, but the Tone-Tag modulation is now more prevalent, and nontagged signals and noise drop a little more than 3 S units. If this isn't enough, the next position moves the floor down 40 dB — nearly 7 S units.

Now, if you're listening to a signal at about S-5 or so and a signal of about the same strength appears at around 400 or 1100 Hz, for example, you are alerted to the fact that the signal is very strong — nearly 16 dB over S-9 and probably suppressing your S-5 signal at his keying rate (if the signal has key clicks, it will be placing energy in a wide band as well). This alerts you to roll back your i-f (often called rf) gain control to avoid probable compression in your receiver's final down-converter (product detector), assuming your first mixer is not also being overloaded. If overloading is present in the first mixer, insertion of some attenuation between it and your antenna is indicated as well. Actually, however, so much attention has been given to the first mixer over the last

*The term antiphasic describes the case where a signal is fed out of phase to your two ears and noise is supplied in phase. The inverse is also true. The usual case (as in monaural reception) is called homosphasic.

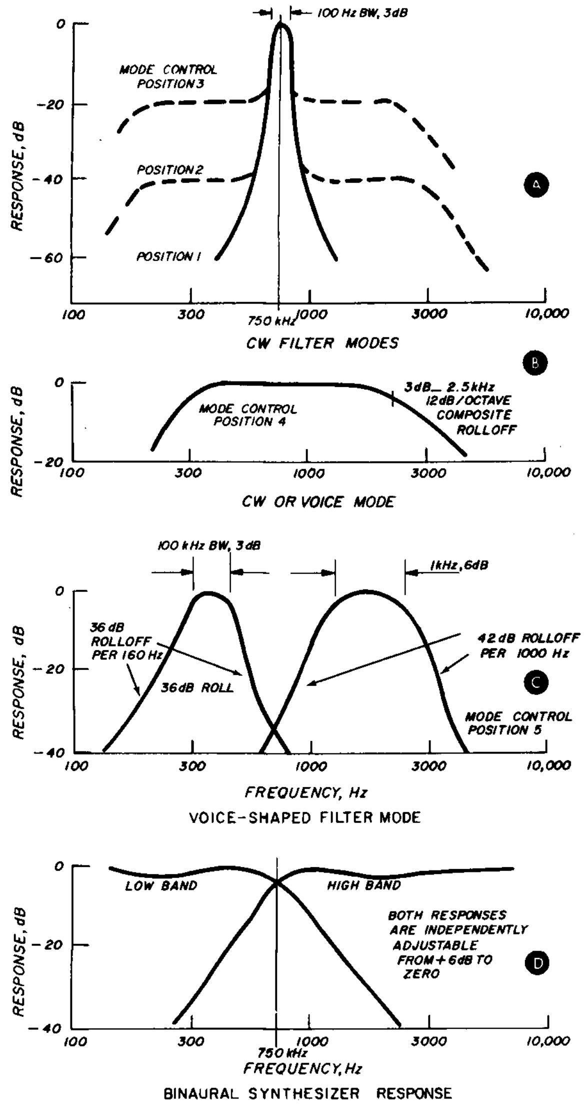


fig. 11. Frequency response. Responses A through C are fed through the response of D to become a binaural function.

two decades that the problem has shifted to the following converter(s) in our current receivers. Corrective action varies somewhat in many receiver designs, but the same general action is taken regardless of whether you are using agc or not.

The last mode select position supplies the basic 9-pole narrowband filter output through the center of the binaural band with no added binaural floor. To make good use of this position usually requires that your receiver have a super-good dynamic range, at least through its product detector.

Tone-Tag may be used or not as you choose in any of the CW modes. In general use, its sensitivity control is advanced to a point of a few degrees above where a given signal is modulated when tuned to the 750-Hz frequency. If no signal is present, increase Tone-Tag sensitivity until background noise is modulated, then back down until the modulated noise is just barely noticed. The best level is also dependent on your receiver audio-output level. Therefore it's possible, after a little experimentation, to generally set the Tone-Tag control on CAP then adjust your receiver gain to the tag level for any signal being received. Tone-Tag's modulator switching uses a nonabrupt design to avoid critical operation and to mitigate the effect of fade generally present on DX signals. In most cases Tone-Tag will make solid those ghostly multi-hop DX signals.

Finally there's the noise control. At the beginning you may nearly wear out this pot. Since the idea of adding noise seems so contradictory, you may constantly test the effect by repeatedly running the noise level up and down when listening to a weak signal. In general, however, a good starting point is found by increasing the soft noise to a point where it's just barely noticeable when the mode control is in the general 2.5-kHz position. The control is left there for all modes. You'll note that the added soft noise power is fixed relative to your receiver gain setting. Through this feature you may vary the ratio of added soft noise to relatively abrasive antenna-derived noise by receiver gain variations.

The binaural function provides a spatial sound environment in all modes without the need for adjustment. In addition, however, with proper physical arrangement and some practice, it can also serve as a tuning aid. For example, in using CAP with a Kenwood TS820S the low-band speaker or headset is placed on the right and the high-band device on the left. In this way, if a signal is heard on the left you know that tuning to the right (clockwise) will move the signal in that direction spatially. This is true with the TS820S because its conversion scheme results in an audio tone that moves from high to low as you turn the knob clockwise. Other receivers will be like this or exactly the reverse. The same may be true when going from band to band (SSB filtering for both voice and CW is assumed). The same tuning directional benefits are also present for SSB voice, although the action is more subtle.

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digital techniques: gate arrays for control

Digital-circuit control sometimes requires a specific set of states. Phase-locked-loop (PLL) frequency-control input is such a condition; the requirement is to translate decimal control to some form of binary output. The example here is control of a "channelized" 10-meter transceiver using a National Semiconductor MM55106 synthesizer package.[1]

Fig. 1 shows the analog frequency control with PLL frequency input switching. Tuning is in 5-kHz increments over the band; no shift between transmit and receive. The receiver i-f circuit is assumed to have a 9-MHz crystal filter. This could possibly be a reworked CB set; the 55106 PLL is designed for such applications.

Both VCO outputs are mixed with one crystal-oscillator output to yield frequencies below the 3-MHz maximum of the 55106. Schmitt trigger NAND gates select the mixed VCO outputs, and filter levels are assumed high enough to cross the Schmitt thresholds.

division control

The PLL allows 5- or 10-kHz increments (hardwired for 5 kHz), with range controlled by programmable divider inputs in binary. Decimal division is obtained by dividing the mixed frequency by five. The range is 152-492 transmit; 168-508 receive, with each converted to binary and applied to the PLL divider input control.

Manual control is through four BCD-coded thumbwheel switches. The 10- and 100-kHz increment switches are standard. The 5-kHz switch is mechanically locked so that it will switch between only 0 and 5; the 0 position may be either 4 or 6 with a decal cover. The 8/9-MHz switch is locked mechanically to those two positions. The 20-MHz position may be assumed, or a dummy switch may be used for appearance.

The MM55106 has nine binary divider control lines. P0 is the least-significant bit, P8 the most significant bit. The LSB controls 5-kHz increments, P1 controls 10-kHz increments; P2 controls 20-kHz increments, and so on. The task is now to translate four decimal digits to one large binary word, including the frequency difference between transmit and receive.

Fig. 2 shows the switch interface for either TTL or CMOS. The switch is conventional BCD with a single common, so that the inverters change a low **ON** (grounded) output to a high state. Pull-up resistors

By Leonard H. Anderson, 10048 Lanark Street, Sun Valley, California 91352

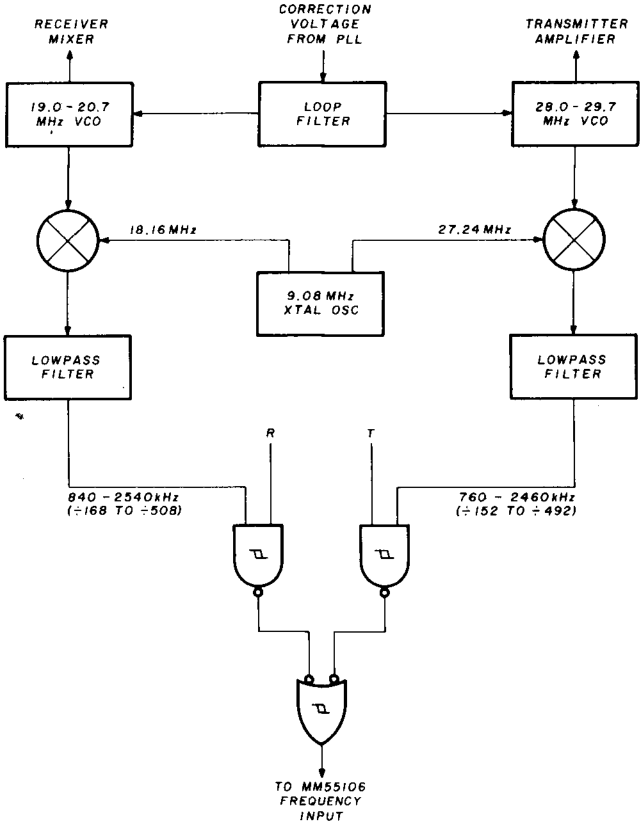


fig. 1. Channelized 10-meter transceiver analog frequency control.

are required, and inverted BCD data is taken from inverter inputs. The 5-kHz and 8/9-MHz switches use only the A switch contact.

translation through addition

TTL packages are available that convert BCD to binary (TI SN74184), but an offset must be provided because the lowest frequency is not zero. The scheme here is to use binary addition for translation with standard packages in TTL or CMOS.

Fig. 3 shows a truth table and schematic for a full adder. A full adder has three inputs. A half adder has only two, using gates G1 and G2 only. Both adders provide a sum and carry out.

Note the Exclusive-OR gates (not mentioned since part one of this series).[2] The truth table shows that inputs A and B are exclusive relative to the sum, and the sum is exclusive with carry in. Two Exclusive-ORs in cascade provide a full sum. Carry out is always generated with both A and B high. The full adder has a carry out with $A\bar{B}$ or $\bar{A}B$ and a carry in.

Single-bit addition is quite simple. A sum occurs with odd numbers of high inputs. Carry out occurs with two or three inputs high. Note that carry in can be treated as just another input. Four-bit binary adder packages are available. A single carry in to the LSB and a single carry out from the MSB is external, with other carries internal. Several packages have high-speed, "carry look ahead" connections for fast arithmetic but aren't required here.

Table 1 shows the required binary states from each selector for addition translation. An interim bit nomenclature is used with A as LSB, H as MSB. The 5-kHz K line is neglected for the moment.

translation in detail

The 10-kHz column of **table 1** is the same as the conventional BCD switch output in **fig. 2**. The 100-kHz column looks more complex, but note that 100 kHz is the next binary state up from 90 kHz: 1010. Two-hundred kHz is binary 10100, or the same as 100-kHz-state with a left-shift. Shifting a binary number to the left is the same as multiplying it by two.

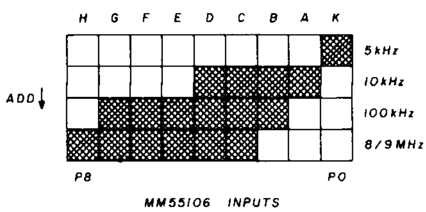
This multiplication with a left-shift allows you to set up an addition of four 100-kHz selector lines to create the six-bit states shown. Some scratchpad work with binary addition will show how the states have been achieved.

The megahertz selector has only two positions. To simplify circuitry, the 8 has been assumed 0 and the 9 assumed 1. A selection of 28.000 would appear to be

table 1. Binary states and addition of selectors.

	10 kHz				100 kHz							5 kHz
position	D	C	B	A	G	F	E	D	C	B	A	K
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1	0	1	0	
2	0	0	1	0	0	0	1	0	1	0	0	
3	0	0	1	1	0	0	1	1	1	1	0	
4	0	1	0	0	0	1	0	1	0	0	0	0
5	0	1	0	1	0	1	1	0	0	1	0	1
6	0	1	1	0	0	1	1	1	1	0	0	0
7	0	1	1	1	1	0	0	0	1	1	0	
8	1	0	0	0	1	0	1	0	0	0	0	
9	1	0	0	1	1	0	1	1	0	1	0	

	1 MHz								
position	H	G	F	E	D	C	B	A	
28 receive	0	1	0	1	0	1	0	0	(84)
29 receive	1	0	1	1	1	0	0	0	(184)
28 transmit	0	1	0	0	1	1	0	0	(76)
29 transmit	1	0	1	1	0	0	0	0	(176)



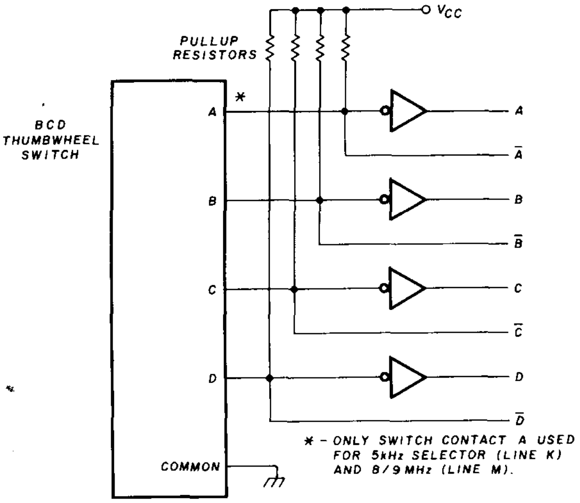


fig. 2. BCD thumbwheel switch interface.

all zeroes, but this won't work. The minimum frequency selected must start with 152 for transmit, 168 for receive; shifting up one megahertz requires adding 200 to each selector. All four-state combinations can be provided with simple gating.

The box with shaded areas in **table 1** shows the bits from each control that will be added for the final division control state. (Note that bits K and A do not add with any others and go directly to the PLL synthesizer).

If you've been paying attention to bit weights (part 5 of this series), you'll notice that values are only half of that required. Including the 5-kHz K line as the LSB will shift everything left once, multiplying by two, and achieving the correct division number.

hardware

Fig. 4 shows the adder grouping and megahertz gating to create the final binary-control state. In this case, megahertz gating is quite simple. Examining **table 1** you'll notice that bit F is the same as M (9-position), while bits C, G, and $\overline{H}$ are the same as $\overline{M}$ (8-position). Bit D is exclusive between M and T (high in transmit). Bit E is created by performing a NAND operation on $\overline{M}$ and T — it will be low only at 28 transmit; high otherwise. All gates except Exclusive-ORs are NANDs.

A half adder sums C_M and S2 from U2. This scheme avoids using an extra four-bit adder. Another package savings is to use the input arrangement for U1 and neglect its carry out. No combination of U1 inputs will result in a carry out; examining all possible states from **table 1** will bear this out.

No adder is used for $\overline{H_M}$ and U3 carry out. Keeping selector controls within band limits holds the maximum divider number to decimal 507 or binary 111111011 for 29.695 MHz receive. No combination of inputs to the adders will yield simultaneous $\overline{H_M}$ and U3 carry, so an OR operation is performed on these two for the P8 MSB. If both were high, it would imply a carry into a tenth bit, which the 55106 cannot handle.

Gates G15 through G20 provide a low state for all frequencies within the band. Sidebands are assumed to be 5 kHz maximum. An interface circuit must disable the transmitter when G20 is high. A high occurs at either 28.000 or 29.7 MHz and higher.

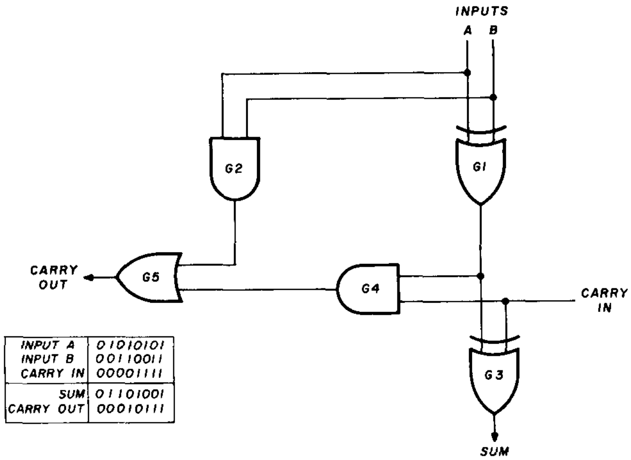
G15 and its inverter performs an AND operation on the zero positions of both the 10- and 100-kHz selectors. G16 expands this action by performing an AND operation on G15 with $\overline{K}$ and $\overline{M}$ to complete a 28.000-MHz gate. Both could be a single 12-input NAND in TTL.

The 100-kHz selector-7 position has an AND performed on it by G17. It does not require a D bit, because BCD states have D as a don't-care for positions 4 through 7. Similarly, gating for positions 8 and 9 could ignore the B and C bits. G18 ORs G17 and $\overline{D_{100}}$ to provide an output high at 700 kHz or higher. This outlet is ANDed with M (9 MHz) for the final high-frequency limit.

design rules

Design boils down to binary-state examination of all inputs *versus* outputs, keeping different package-function capabilities in mind. Intermediate states should be considered, as in the case of ignoring the U1 carry out. Different arrangements might be an advantage. **Table 2** provides a list of devices with equivalent functions.

As an example, four adders instead of three would eliminate G12, G13, G14, and two inverters. The single remaining Exclusive-OR, G10, could be replaced



INPUT A	01010101
INPUT B	00110011
CARRY IN	00001111
SUM	01101001
CARRY OUT	00010111

fig. 3. Full adder truth table and schematic.

table 2. Device equivalent-function part numbers.

	TTL	CMOS
hex inverter	7404	4069
quad exclusive-OR	7486	4070
quad 2-input NAND	7400	4011
triple 3-input NAND	7410	4023
dual 4-input NAND	7420	4012
8-input NAND	7430	4068
4-bit adder	7483	4008
quad 2-input NAND Schmidt trigger	74132	4093
BCD-to-decimal decoder	7442	MM74C42*

*National Semiconductor part. 4028 CMOS decoder has active-high outputs while 7442 has active-low outputs.

by two NANDs. Package count is the same, but some spares are available.

Another alternative takes advantage of the offset difference of 16 between transmit and receive. This is the fifth highest binary bit. Four adders are used with direct M and $\overline{M}$ inputs plus an extra D bit input from $\overline{T}$ to add the difference in receive; G10 through G14 are deleted. This case is possible only because all binary states C through H, for 28 and 29 transmit, are opposite. Only the transmit states are used, because adding 16 creates receive states.

Certain cases may have the added control lines in a state higher than desired. Addition is still possible by using only those bits desired and the following expression in decimal numbers:

$$P + D - S = A$$

where P = maximum binary control input plus one
D = desired number for control input
S = control switch number
A = offset number to be added to all others

An example has $S = 400$ with desired D to be 170 and 9 binary lines. Nine binary bits yield 511 ($2^9 - 1$), so P is 512. The offset to be added is 282 decimal, or 100011010 binary. All carries beyond the 9th bit would be ignored.

A 6- or 2-meter control needs four megahertz positions. Only switch bits A and B are needed; see **table 1** for 0-3 and 4-7 positions. A BCD-to-decimal decoder with active-low outputs could be used with its C bit input as the transmit/receive line. The decoder's eight outputs could then be ORed with NANDs for the necessary states. This package was originally de-

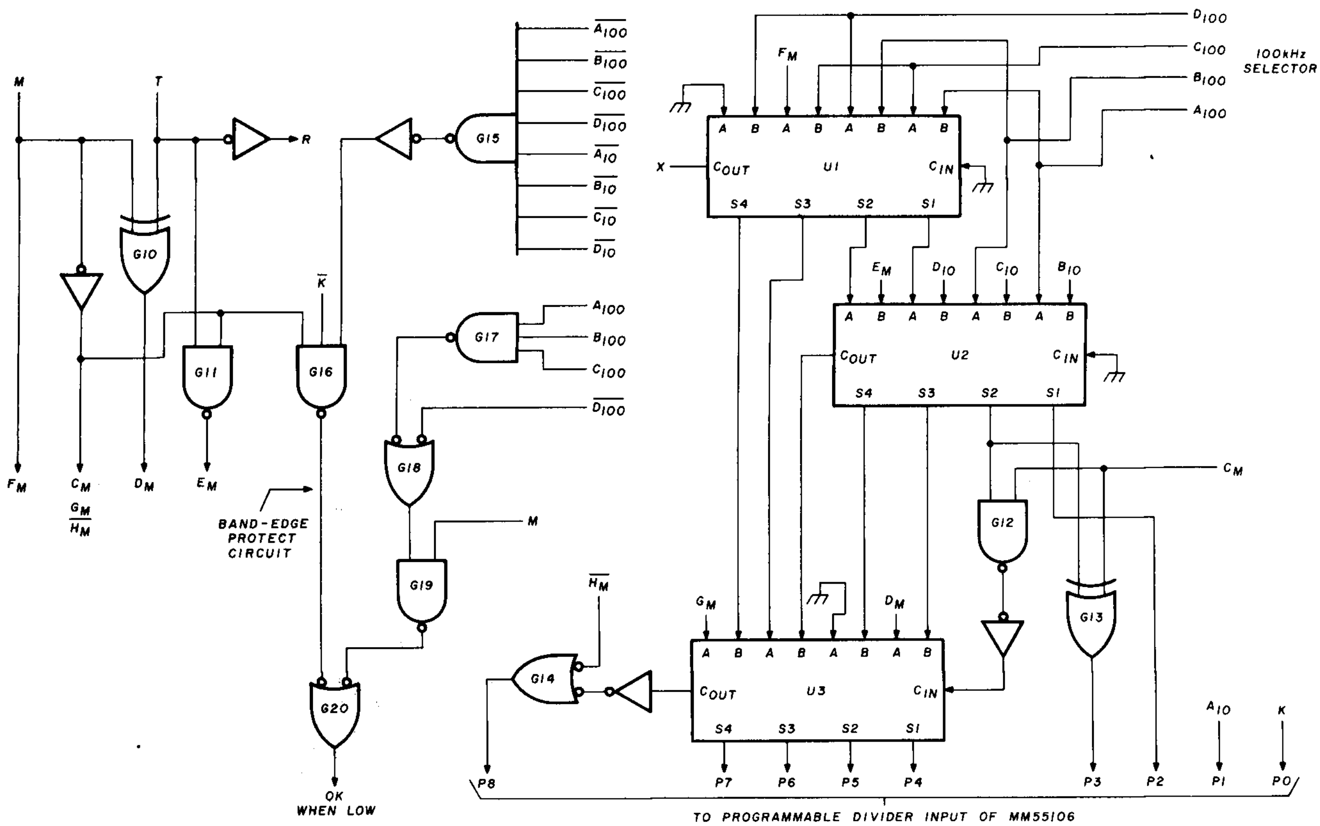


fig. 4. Translation gating and adders for MM55106.

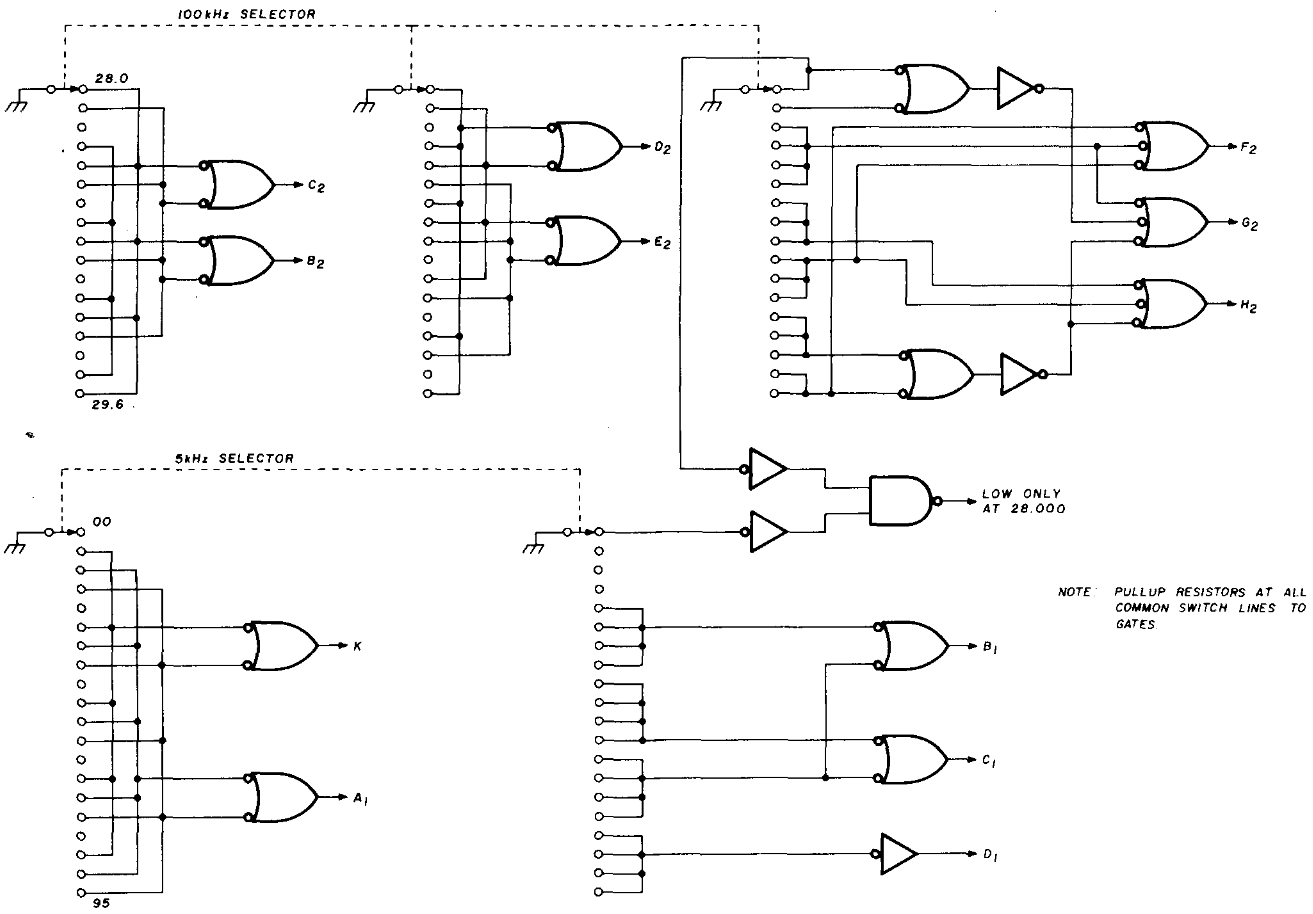


fig. 5. Dual rotary switch circuit equivalent of BCD thumbwheel selectors.

signed as a decimal indicator decoder but will work very well in this application. You might think a decimal switch would work best here. This is true for manual control, but automatic tuning from an up/down counter array needs some form of decoding.

another manual control

Two rotary switches can be used in the 10-meter rig. One can be seventeen positions for 100-kHz increments of 28.0 to 29.6 MHz, while the other can be twenty positions for 5-kHz increments. Indicator dials with adjacent edges can display a continuous number at any position.

Cam-actuated leaf or microswitches are the least troublesome. PC wafer-contact types are good but expensive. An alternative is a pair of 15-degree index rotary switches with stator contacts wired as in **fig. 5.**

The dual-rotary circuit uses NAND-gate ORing to produce a high from grounded inputs. Pull-up resistors are required for all gate inputs. The 5-kHz selector produces BCD states in A_1 through D_1 plus K for the LSB. The 100-kHz selector generates transmit states of decimal 76 to 236 (152 to 472 when left-shifted) in B_2 through H_2.

ORed switch contacts feed two four-bit adders with overlap occurring only in bits B, C, and D. An E bit input would come from $\overline{T}$, as in the other circuit, for the difference of 16 between transmit and receive. The second adder inputs for bits F, G, and H would be grounded. Band-edge protection is needed only at 28.000 MHz, because the high band-end is automatically controlled through the detent stop.

Many different ways are available to make a complex control input. Regardless of function, all designs must consider the required output, desired input control, and various possibilities of control and package functions. Binary-state examination is not only necessary, but will also provide a good basis for troubleshooting.

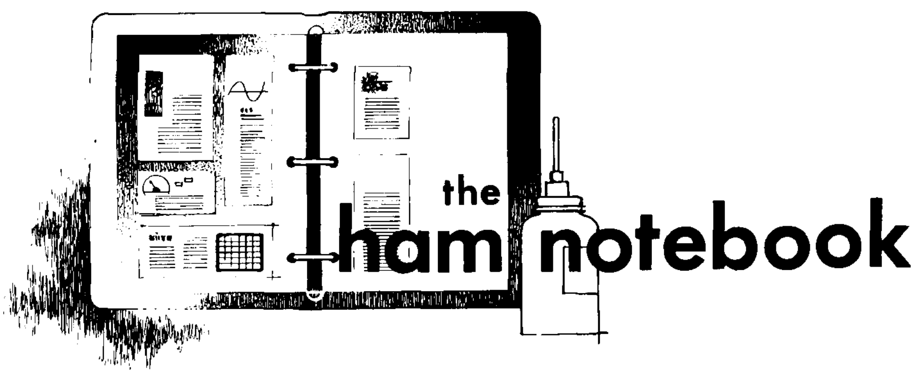
references

1. *CMOS DATABOOK*, National Semiconductor Corporation, 1977, pages 4-22.

2. Leonard Anderson, "Digital Techniques: Basic Rules and Gates," *ham radio*, January, 1979, pages 76-78.

ham radio

More Details? CHECK—OFF Page 110



reducing interference in the TS-820/TS-820S

The TS-820 modifies the audio response when switching from SSB to CW; the CW response is peaked at about 1000 Hz. This response is often useful in SSB reception as a way of reducing interference.

The peaked response is obtained by grounding lead CWG of the audio board (pin 4 of AF1). The ground should be one of the audio grounds; MEG or pin 12 of IF4 is the one normally used.

Those with the TS-820 can use the DISPLAY HOLD switch for this purpose. For the TS-820S, the unused contact pair on this switch could be used; this would require turning on the HOLD control whenever the modified response is desired for SSB, which is probably satisfactory. Alternatively, an external switch can be used.

R. P. Haviland, W4MB

improved CW agc for the Ten-Tec Omni-D

Shortly after receiving a new Ten-Tec Omni-D transceiver, I noticed that the agc time constant remained unchanged whether operating ssb or CW.

Upon examination of the i-f agc circuit, it became apparent that adding a resistor in parallel with C22, on the i-f agc circuit board, would decrease the recovery time. A value between 100k and 1 meg will work fine depending on your CW agc requirements. I used a 220k resistor.

Switching this resistor in, in the CW mode only, was accomplished by adding another wafer to the mode switch. The two wafers presently mounted on this switch are both double-pole six-position, with only four positions used. There's plenty of room on the mode switch shaft for the additional wafer, but you'll have to use 6-mm (1/4-inch) longer M3 (4-40) round-head screws to mount it. I purchased the additional wafer, which is also double-pole six-position, directly from Ten-Tec, although there may be other sources I'm not aware of.

I added the resistor from one of the stringers of the new wafer to ground on the front panel. I then soldered a piece of hookup wire between the high side of C22 on the i-f agc board and the CW position on the new wafer. Be sure to use the same switch on this wafer; there are two, unless you purchased the single-pole type.

According to Ten-Tec, this modification will not void your warranty.

Don McDougall, W6OA

salvaging water-damaged coax cable

The effectiveness of the shield braid on coaxial cables depends on the wires remaining bright and shiny so that the individual conductors remain in constant contact with each other throughout the entire feedline length. When coaxial line becomes contaminated, through damage to the outer plastic jacket, improper sealing of line terminations — or, even worse — no sealing at all, water will enter the line and can eventually penetrate the full length through capillary attraction, the braid acting like a metal sponge.

Such contamination renders the line unserviceable for rf applications, as the moisture soon corrodes the individual braid wires, destroying the surface continuity necessary for effective shielding. Characteristic line impedance changes, as the center dielectric becomes a combination of water, plastic, and corrosion. Rf losses increase drastically.

If contamination isn't extensive, it may be possible to cut off the contaminated portion to the point where the braid is again bright and shiny. This should be followed by at least a loss test: feeding a known power through the line and measuring the power delivered at the load. The results can then be compared with published specifications for loss at a specific frequency. However, replacement of the line and careful attention to sealing should be considered. A simple line-loss test ignores many important factors.

Although no longer serviceable for rf, water-damaged coaxial line, especially heavier lines such as RG-8/U or RG-213/U, may find other applications, especially for low-voltage, high-current dc.

Military specification requirements for RG-8/U and RG-8A/U lines originally required that the center conductor be composed of seven strands of 0.03-inch (0.76-mm) bare copper. This provided a twisted conductor of 0.09-inch (2.3-mm), approximately equal to no. 12 (2.1-mm) solid copper in current-carrying characteristics. Braid specifications required 192 strands of no. 33 (0.16-mm) bare copper wire, the combined circular mill area of which is only slightly smaller than a no. 10 (2.6-mm) solid copper wire.

Paralleling the center conductor and braid produces a single conductor with a CMA of 15270 cm, larger than a no. 9 conductor and only slightly smaller than no. 8. RG-213/U cable used in this manner will have a CMA equivalent almost identical to no. 8 copper wire.

Current-carrying capability of such cable will depend on many factors (such as ventilation), but it should carry at least 60-70 amps continuously and much higher currents for shorter periods of time. This makes salvaged cable useful for heavy-current cable in mobile equipment or for use in grounding applications.

For such applications soldering will be essential but will be complicated by the corrosion. Usually the corrosion may be removed by dipping the exposed braid and center conductors in a chemical cleaner such as those for cleaning silverware and copper kitchen utensils. After dipping, wash the cleaned copper in water and it will solder easily.

Add four heavy battery clamps to short lengths of salvaged coax and you can homebrew battery jumper cables for light-duty service.

Many currently manufactured coax cables have much fewer wires in the braid, so before using salvaged coax check the braid closely. It may be necessary to derate its current-carrying capability if it doesn't provide approximately 95 per cent coverage.

Robert Wheaton, W5XW

measuring air pressure across transmitting tubes

As Bill Orr notes (June, 1979, *ham radio*) inadequate cooling of air- cooled transmitting tubes may be dangerous for their health. After long deliberation I hit upon a convenient way to measure this air pressure.

Remove the innards of a single-hole-mount BNC connector (UG-1094) and mount it at some convenient spot in the pressurized compartment. To measure air pressure, slip the end of a short length of 9.5-mm (3/8-inch) ID clear plastic tubing over the connector. Insert the other end into a glass of water to the point where air bubbles stop. Measure the length of tube in the water: this is the air drop. When finished, close off the opening with a male BNC cap, which can be removed any time.

By the way, a convenient way to bring air to a chassis is through the flexible tubing, 64 mm (2-1/2 inches) in diameter, used on shop-type vacuum cleaners. The tubing and end fittings, suitable for mounting on plenum chambers and chassis, are available as replacement parts. *Shop-Vac* 2-1/2-inch (64-mm) diameter flexible hose in 6-foot (1.8-meter) lengths is part number 1722, and their 2-1/2-inch (64-mm) flange ferrule fittings, which are easy to mount with standard hardware, are part number 1714. A Y joint is available to direct air from one source to two chassis.

One of the surprises in measuring air pressure was that the popular muffin fan develops an insignificant amount of air flow for the 4X250B.

Guy Black, W4PSJ

modifications to the Wilson Mark II and IV

The Wilson Mark II and IV 2-meter handheld transceivers are fine units; they have excellent battery life and a very good receiver. For those with the early version, there have been some factory changes for which modification kits can be obtained from Wilson. The kits are for the HI/LOW power switch located on the bottom of the unit and a battery-condition LED that blinks as batteries get weak. Both are good features.

plug-in crystals

One drawback of these transceivers is that you must solder the crystals into the PC board. This presents problems in emergency situations and when traveling. It would be much better to open the case and quickly exchange at least a few channels. Crystals with a six-position switch make this unit easier to use in the dark or in an emergency — compared with those that use no crystals and take forever to dial up that needed frequency. In the dark it's just plain impossible!

When investigating this quick-change in my Mark IV, I located a supply of some subminiature crystal jacks. These work very nicely. It takes longer to explain how to install them than to do the job. I installed three channels; most of the hams in the area installed all six channels.

installation

Open the unit and remove the crystals from the channels for which you wish to have plug-in capability. Enlarge the existing holes with a no. 48 1.95-mm (0.076-inch) drill. These new holes will be slightly larger than needed, but we want a margin of freedom between hole and jack. Drill from the track side of the board to be sure not to disturb the copper track from the laminate.

The best way to solder the modification jacks is to use a crystal with the jacks mounted on the pins. Insert the assembly into the enlarged holes. Solder the crystal assembly and proceed with the next assembly.

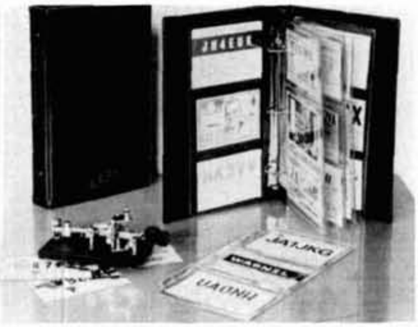
After installation some units seemed to require a little pressure when closing the case. This is because of the varying thickness of the rear case/battery compartment. In these units, I affixed a piece of white paper and a carbon to the rear case with the carbon toward the paper, so that when the case is closed the crystal jack ends will press onto the carbon and paper, marking the paper where there is contact. With the dots on the paper as a guide, use a 3-mm (1/8 inch) drill and remove a *very slight* amount of plastic from that point. Not much is required. This should allow you to reassemble the handheld. I've a supply of subminiature crystal jacks at $0.15 each.

Don Smith, W9EPT/AAM9EPT

More Details? CHECK—OFF Page 110

NEW products

QSL organizer



With today's more sophisticated rigs and less cluttered radio shacks, how do you keep QSL cards neatly organized, well preserved, dog-ear resistant, and always on beautiful display?

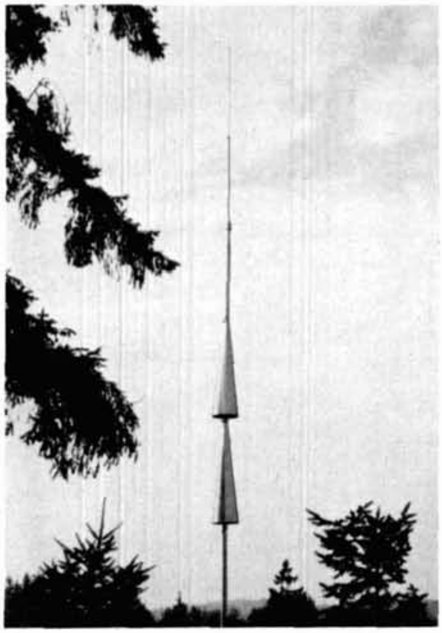
A specially designed Organizer is now available from Mil Industries of Panorama City, California. The QSL Organizer contains heavy duty plastic pages with roomy 10 × 15 cm (4 × 6 inch) slip-in pockets. Each page holds six QSLs (back to back), enhancing their appearance by its crystal clear clarity. The slip-in pockets allow cards to be arranged or rearranged quickly and easily.

The QSL Organizer Album is specially designed to hold the slip-in pocket pages. It's a beautiful three-ring binder, richly padded in long-lasting "Brown-Hide" vinyl, with gold-printed inscription on cover and spine. Pages are easily inserted or removed.

The clear vinyl-pocketed pages are sold by Mil Industries at 47 cents each, with a 40 page minimum. The QSL Organizer Album is included free with every 40 pages ordered. Larger quantity prices are available on request. The QSL Organizer comes with a full, money-back guarantee.

QSL Organizers serve an important function in today's radio shack. They also make great gifts and great prizes for clubs and hamfests. They are available from Mil Industries, P.O. Box 44457, Panorama City, California 91402.

ISOPOLE antenna



Advanced Electronic Applications, Inc., has developed the ISOPOLE,* a new, vertically polarized, omni-directional, gain-type, base-station antenna which provides performance superior to that of any other low-cost antennas now in the marketplace. ISOPOLE's revolutionary double cone design results in virtual elimination of the major problem plaguing other base-driven vertical antennas, the inadvertent and unwanted coupling of rf currents onto the supporting structure and the shield of the feedline, seriously degrading the radiation patterns of most antennas. On-the-air tests have shown a substantial signal improvement in favor of the ISOPOLE.

*ISOPOLE is a registered trade mark of AEA.

The ISOPOLE's unique new design features a double-decoupled, center-driven, 1¼-wavelength antenna to provide the theoretical maximum obtainable gain for a dipole. All rf connections are protected from the weather. The ISOPOLE is pre-tuned at the factory so that the user can obtain an 8-MHz bandwidth by following the simple assembly instructions. The ISOPOLE is intended for installation atop the swaged end of a standard TV mast (not supplied). The ISOPOLE has a net price of $49.95. Available for 144 and 220 MHz.

For further information, contact Advanced Electronic Applications, Inc., P.O. Box 2160, Lynnwood, Washington 08036; phone (206) 775-7373.

new RCA MRO semiconductor replacement guide

A new booklet listing most of the Semiconductor devices available for MRO (maintenance and repair operations) of industrial and electronic equipment has been announced by RCA's Distributor and Special Products Division, Deptford, New Jersey.

The identical replacement transistors, and other solid-state devices listed in the booklet are available from distributors of RCA SK series. The MRO Industrial/Commercial Replacement Semiconductor Catalog/Data Booklet (1K5817) is available from RCA SK-Series distributors, or orders can be sent to SK Series Merchandising, RCA Distributor and Special Products, P.O. Box 100, Deptford, New Jersey 08096, with check or money order for $1.00 per copy.

Radio Shack receiver

Now available from Radio Shack is a new general-coverage communications receiver that puts the world at your fingertips by letting you listen to shortwave radio broadcasts, as well as Amateur Radio operators, CBers, aircraft weather stations, maritime broadcasts, and more.

Shortwave listening opens up a new world of entertainment for you, and it can be educational as well as entertaining. News programs from other countries provide the listener with different perspectives on world events, and it is possible to learn about the customs, culture, music, and languages of other nations through short-wave listening.

The Realistic DX-300 general-coverage communications receiver features LED (light emitting diode) digital frequency display that makes it easy to tune to a specific frequency, or return to it whenever you wish.

Quartz-synthesized circuitry provides extremely stable, virtually drift-free reception as well as highly accurate tuning. A six-band preselector with built-in six-element ceramic filter and a three-position audio-bandwidth control sharpens selectivity and reduces signal interference.

The receiver tunes from 10 kHz to 30 MHz, and can receive a-m, upper and lower sideband, and CW (code). It operates from 120 Vac, 12 Vdc, or from eight self-contained "C" cells. A dial light/battery switch reduces battery drain during portable operation, and also indicates battery condition on the Signal-Strength/Battery meter.

Other features include a three-step rf attenuator to prevent overloading, rf gain control, built-in speaker, headphone jack, and a key jack for the built-in code practice oscillator. The heavy-duty cabinet has a recessed carrying handle.

The Realistic DX-300 general coverage communications receiver is priced at $379.95. It's available from participating Radio Shack stores and dealers nationwide.

More Details? CHECK—OFF Page 110

transceiver protector

Expensive transceivers are prone to damage by unsafe input voltages when the line-operated power-supply regulator fails. "Crowbar" by K2OM is designed to sense the harmful overvoltage and short circuit the dc power-input lines to ground.

When used to protect a transceiver at 13.8 volts, Crowbar will trip and short circuit at a preset level of 15.5 volts, blowing the line fuse.

Trip levels can be adjusted from 6 to 30 volts by a control provided on the printed-circuit-board assembly. Two flexible color-coded connection wires tie into the user's equipment. Mounting hardware is supplied. An assembly and installation booklet comes with the unit.

Manufactured by Daltec Systems Incorporated, "Crowbar" is available from stock, assembled and tested (Model CA630A), for $15.00. Dealers contact Unadilla/Reyco Div. of Microwave Filter Co., 6743 Kinne St., E. Syracuse, New York 13057. Individuals write Daltec Systems, Inc., P.O. Box 157R, Onandaga Branch, Syracuse, New York 13215.

new MFJ catalog

The new MFJ Amateur Radio Catalog for 1980 is available free from MFJ Enterprises, Inc., the nation's leading manufacturer of Amateur Radio accessories.

The products included are antenna tuners (from 200 watts to 3 kW); SSB and CW filters (from $29.95 to $79.95); memory keyers (3 models, $79.95 to $139.95); electronic keyers (from $39.95 to $69.95); speech processors, rf noise bridge, frequency standard, code practice oscillator, and QRP transmitter.

This new catalog has 12 pages of photographs, descriptions, specifications, and prices of Amateur Radio accessories manufactured by MFJ Enterprises, Inc.

The catalog is free, and available by writing to MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

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8 TO 12 GHz GaAs FET AMPLIFIER. Narda N6205S-6. Small signal gain: 25 dB. Noise figure: 7.5 dB. Power output: + 10 dBm. Excellent lab unit. SMC connectors. 15 V dc. Harold Winard, KB2M, 30 W. Union Tpk. B-8, Wharton, NJ 07885. (201) 361-6478.

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ONLY MY FRIEND'S recent physical disability makes this top-grade equipment available; purchased new, still in as-new condition, complete with manuals/cables. Bill had literally a store full of items, $10 to $100 range; too costly to advertise the list, so tell me what you need. I want to move them now. Anyone having a difficult time learning code and operating CW? These like-new visual decoders and electronic typewriter keyboard: Pickering 230-D Morse Decoder, $1500; Pickering KB-1 Electronic Keyboard keyer, $140; Atronics CR-101 Code Reader, $65; manuals/instructions. Collins: 51S1F, $2050; 55G1, $325; 30L1, $995; 32S3A/516F2, $1775; 312B4, $425; all Round Emblem, immaculate w/manuals. Two Hy-Gain HT-18, 10-80 meter vertical antennas, $195 each (phasing harness available); Two Murch Ultimate Transmatch UT-2000A, $125 each; DenTron 3000A antenna tuner, $230; KLM Multi-2700 144 MHz transceiver, $575; KLM PA 10-140BL linear amplifier, $175; Vista 120v.a.c./13.8v.d.c. power supply for above, $136; excellent condition w/manuals. Ralph E. Thomas, W2UK, 9 Emmons Avenue, Farmingdale, N.J. 07727; telephone (201) 938-5623.

AFC — STOP VFO DRIFT. See June '79 HR. Complete unit $49.95 + shipping. Read Easton, K6EHV, 3691 Gay Way, Riverside, CA 92504.

WANTED: A Heathkit HW-20 2-meter AM transceiver (the "Pawnee") in working condition. Al Gordon, 1726 Spreckels Lane, Redondo Beach, CA 90278.

QSL CARDS 500/$10. 400 illustrations, sample. Bowman Printing, Dept. HR, 743 Harvard, St. Louis, MO 63130.

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HAM RADIO REPAIR, alignment. Prompt, expert, reasonable. "Grid" Gridley, W4GJO, Route 2, Box 138B, Rising Fawn, GA 30738.

WANTED: Motorola KXN1024A channel elements. WB0IKS, Dave Borchard, 4362 Thomas Ave. N., Minneapolis, MN 55412. (612) 521-0438 evenings.

RTTY AFSK Modulator PC board. See Feb. 79 Ham Radio. Drilled $5.00 F. E. Hinkle, 12412 Mossy Bark, Austin, TX 78750.

More Details? CHECK—OFF Page 110

NEW FALL 1979 Test Equipment Catalog available. 108 pages of quality used equipment. Write for free copy. Tucker Electronics Co., Box 401060, Garland, TX 75040.

THE MEASUREMENT SHOP has used/reconditioned test equipment at sensible prices; catalog. 2 West 22nd St., Baltimore, MD 21218.

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WANTED AFSAV-133D & AN/FRA-86 Demods TD-687 Demux, AFSAV-129A Selector & AFSAV-39C Rekeyer. C. T. Huth, 146 Schonhardt, Tiffin, OH 44883.

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DX, YOU BET! THE DX BULLETIN — Best weekly DX info in the world. For FREE sample copy, send business-size SASE to: The DX Bulletin, 306 Vernon Avenue, Vernon, Connecticut 06066.

WANT TO START QRP (Low Power) Ham Magazine. Anyone interested in subscriptions and/or contributing articles, write: Lynn Woods, 1435 W. 25th, #6, Anchorage, Alaska 99503.

ROHN TOWER — Buy wholesale from Worldwide distributor. 20G $27.06 section; 25G $37.62 section; 45G $67.76 section; 48 ft. foldover tower, $605.00; 48ft. BX free-standing $213.40. Hill Radio, 2503 GE Road, Box 1405, Bloomington, IL 61701. (309) 663-2141.

75S-3B, 32S-3 and 516F-2 winged. Excellent condition. All manuals. $1295. Stan Huber, W7NOI, 318 Steven Ct., Benicia, CA 94510. (707) 745-8089.

NORTH AMERICAN DX REPORT — free sample — SASE to Suites R2-R3, 615 S. Frederick Ave., Gaithersburg, MD 20760 — Phone (301) 840-1987.

CW FILTERS: Active audio 8-pole, install in any radio, selectable bandwidth, $15-$32. SASE info W8CBR, 80W. Mennonite, Aurora, OH 44202.

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WANTED: AFSAV-39C keyers, AN/FRA-86 & AFSAV-133 demods., and type "N" coaxial bulkhead lightning arresters. C.T. Huth, 146 Schonhardt St., Tiffin, OH 44883.

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SELLING OUT — Collins KWM-2, 516F-2, sealed relays, excellent $650. Drake DSR-2, New $1895. Icom 701S, P/S, Mike, Mint, as New, $1200. IC-RM-2, New $150. Astro 200A, Console, P/S, Touch-Tone mike, as New $925. All FOB, prices firm. WA6NWP, 52632 Rd. 426, Oakhurst, CA 93644.

Coming Events

MICHIGAN: Oak Park A.R.C. Annual Swap 'n' Shop, Sunday, January 13th, 8 A.M. until ??? at the Oak Park High School on Oak Park Boulevard. For information, reservations, table space, etc., write Ray Previ, Oak Park A.R.C., 14300 Oak Park Boulevard, Oak Park, Michigan 48237. Talk-in on 146.52 simplex; information 146.04/.64.

More Details? CHECK—OFF Page 110

INDIANA: Hamfest Swap & Shop, January 6, first Sunday after New Year's Day, New Century Center, U.S. 31, South Bend. Tables $3 each. Food service, automobile museum and Art Center in same building. Four lane highways to door. Talk-in 146.52-52, 13-73, 34-94, 147.99-39, 87-27, 69-09.

WISCONSIN: The 8th Annual Midwinter Swapfest of the West Allis Radio Amateur Club, Saturday, January 19, 8:00 A.M., Waukesha County Expo Center, Waukesha. Refreshments, cash prizes. Tickets: $1.50 advance; $2.50 door. Reserved tables $3.00 (4 ft.). Write: 1980 Swapfest, P.O. Box 1072, Milwaukee, WI 53201.

"FREEZE YOUR ARCTIC OFF" expedition sponsored by the Ford Tin Lizzy Club, North Metro Chapter, January 19. The club will be operating from Lake St. Clair near the US-Canadian border. Operations from 2000 GMT January 19 to 1500 GMT January 20. Callsign AD8R. Principal operating frequencies: 7.275 MHz. SSB plus 21.380 MHz if propagation allows. Also 2 meters on 146.52, .55 and .58 MHz. All QSL's acknowledged with 8" × 10" certificate commemorating this event. No SASE necessary. QSL to Box 545, Sterling Heights, MI 48078.

1980 CLASSIC RADIO EXCHANGE sponsored by the Southeast Amateur Radio Club of Cleveland, Ohio. Contest starts 2100 UTC January 27th and continues to 0400 UTC January 28th. Exchange name, RST, state/province/country, receiver and transmitter type, and other interesting information. CW call CQ CX and phone call CQ EXCHANGE. Frequencies: CW, up 60 kHz from low edge; phone, 3910, 7280, 14280, 21380, 28580; Novice/Tech: 3720, 7120, 21120, 28120 kHz. The object is to restore, operate, and enjoy older type radio equipment built since 1945, but not "younger" than ten years of age. Full information from Stu Stephens, 1407 Hollyrood Road, Sandusky, Ohio 44870.

GET RID OF YOUR WINTER DOLDRUMS! Attend Wheaton Hamfest Portable Nine sponsored by the Wheaton Community Radio Amateurs Club on Sunday, January 27, 1980, at the Arlington Park EXPO Center at the Arlington Heights Race Track, Arlington Heights, IL. 300 free flea market tables will be available; 100 commercial booths (for booth info call WB9TTE 312/766-1684). Acres of clear paved parking (the EXPO center has its own snow removal equipment!!) Hourly door prizes! Tickets $3 at door; $2 advanced. Send S.A.S.E. to W.C.R.A., Box QSL, Wheaton, IL 60187. Doors open at 8:00 a.m. sharp!

THE RICHMOND FROSTFEST III, sponsored by the Richmond Amateur Telecommunications Society will be held Sunday, January 13, 1980, at the Bon Air Community Center. Homebrew contest with four awards, Most Original Idea, Best Electrical Work, Best Mechanical Work and Most Deserving Work. Prizes. FCC Exams start at 10 AM and completed forms 610 must be received in the Norfolk Office of the FCC at 870 North Military Highway, Bank of Virginia Bldg., Norfolk, Va. 23502 no later than January 9th. Admission is $3.00, indoor Flea Market tables $3.00, tailgaters $2.00. Talk-in 28/88 and 34/94. Richmond Amateur Telecommunications Society, P.O. Box 1070, Richmond, Virginia 23208.

JANUARY 19, 1980, Sharon, Pa. Get rid of your post-Christmas blues! Attend the Third Annual Mercer County Amateur Radio Club Seminar to be held at the Holiday Inn of West Middlesex, Pa. off I-80. 9:00 a.m. to 5:00 p.m. Come to hear speakers on your favorite amateur radio topics. Door prizes. $2.00 advance registration. $3.00 after January 11. For further details write: K3LA, P.O. Box 673, Sharon, Pa. 16146.

SOUTH CAROLINA QSO PARTY. 1800Z Saturday, February 2nd through 2400Z Sunday, February 3rd. Same station can be worked each band, each mode. S.C. stations can work other in-state stations. Exchange RS(T) and QTH; county for in-state contacts and state, province or country for others. Frequencies: CW — 3550, 3710, 7050, 7110, 14050, 21050, 21110, 28050 and 28110 kHz; PHONE — 3980, 7280, 14280, 21380, and 28580 kHz. No repeater contacts. Information from Elliott Farrell, Jr., WA4YUU, Box 994, Walterboro, S.C. 29488.

QSL EXCHANGE CONTEST RULES: Contest period is from 0000 UTC January 5, 1980, (1900 EST January 4) to 2359 UTC January 6 (1859 EST January 5). All modes. Exchange of call signs and signal reports, accompanied by the statement "I have completed your QSL card" (or QSL done on CW). Make sure the other station is actually in the QSL Exchange Contest and is filling out your card at the same time. CQ QSL TEST is suggested as the call. All QSL cards must be mailed to: H.W. Barry Merrill, W5GN, 10717 Cromwell Drive, Dallas, TX 75229, include SASE. Sort QSL cards by call district, then suffix, then prefix. Entry must be accompanied by $1.00 for every 100 QSL cards.

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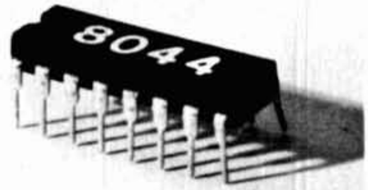

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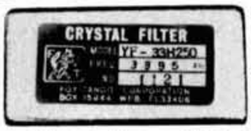

Whether your SSB rig is old or new, there is no easier or essentially less expensive way to significantly upgrade its performance than by improving its IF passband filtering. FOX-TANGO filters are made of specially-treated high-Q quartz crystals, affording excellent shape factors and ultimate rejection exceeding 80 dB. They are custom made for drop-in installation; matching perfectly, both physically and electronically. Our Diode Switching Boards make possible (now or in the future) the addition of a variety of switch-selectable filters affording superior variable bandwidth without the need to buy an expensive new model. If you want the best for less, you'll buy FOX-TANGO. Just tell us the bandwidth(s) desired for your make and model.

8-POLE FILTER BANDWIDTHS IN STOCK

MAKE AND MODEL OF SET	CW (Hz)[1] 125	250	400	500	600	800	SSB-AM (kHz)[2] 1.8	2.1	2.4	6.0	8.0	SEE NOTE #
YAESU	$55 EACH											3
FT-101/F/FR-101		✓		✓	✓		✓		✓	✓		
FT-301/FT-7/B		✓		✓			✓		✓			
FT-901/FT-101ZD		✓		✓			✓			✓		
FT-401		✓		✓			✓	✓				4
KENWOOD	$55 EACH											3
TS520/R599		✓	✓				✓					
TS820/R820		✓	✓				✓	*	2nd IF			5
HEATH	$55 EACH											3
ALL BUT SB104		✓	✓				✓	✓				
DRAKE	FOR PRICES SEE NOTES											3
R-4B/C	GUF-1				(BROAD 1st IF)					✓	✓	6
	GUF-2				✓	✓	(NARROW 1st IF)					7
	✓	VERY SHARP CW (2nd IF)										8
		GUD — PRODUCT DETECTOR KIT										9
COLLINS:	SPECIAL $125 EACH											3
75S-3B/C		✓	EQUALS OR EXCELS $400 COLLINS UNIT									10

NOTES:

1. a) **250 Hz Filters.** Considered to be very **sharp**; ideal for DX and contest work. Excellent for crowded band conditions, yet not too narrow for ordinary operations. Though superior to audio-type filters, crystal filters work well with them.
   b) **400 and 500 Hz Filters.** Slightly narrower than "standard" units supplied as options. However, Fox-Tango filters are 8-pole, unlike the 6-pole (or less) ordinarily available. Through the use of Diode Switching Boards, both standard-type and sharp (as well as SSB) filters may be used on a switch-selectable basis for flexible operation.
2. a) **1.8 kHz Filters.** Intended to supplement (or supplant) standard SSB filters whose bandwidth is about 33% greater. Useful in overcoming QRM.
   b) **2.1 kHz Filters.** Provide a modest improvement over broader standard units, but even where the same bandwidth, the superior Fox-Tango characteristics greatly improve performance.
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   d) **6 kHz Filters.** Essential for quality reception of short-wave broadcasts, CB signals, etc. ordinarily almost unintelligible when SSB filter is used.
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5. Filter marked with star (★) is a new 455 kHz 2nd IF unit for **superior** R-820S SSB. Similar in quality to Collins unit below. **Introductory price:** $125 each.
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10. Special plug-in unit equals or exceeds specifications of $400+ Collins X455Q200. **Special:** $125 each.

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A. E. A. ___ 677
Aluma ___ 589
Astron ___ 734
Atlantic Surplus *
Barry *
Bencher ___ 629
Bilal ___ 817
Budwig ___ 233
Comm. Assoc. *
Communications Center ___ 534
Comm. Concepts ___ 797
Comm. Spec. ___ 330
Continental Spec. ___ 348
Creative Elec. ___ 751
Curtis Electro ___ 034
DCO ___ 324
DSI ___ 656
Daltec Sys. ___ 813
Data Signal ___ 270
Dave *
Daytapro ___ 455
Digital Equip. *
Drake *
EBA Microwave ___ 818
E. T. O. *
Erickson *
Fair Radio ___ 048
Fox-Tango ___ 657
G & C Comm. ___ 754
GLB ___ 552
Gregory *
Hal *
Hal-Tronix ___ 254
H. R. B. ___ 150
H. R. Magazine ___ 150
Henry ___ 062
Hildreth ___ 283
Icom *
Int. Crystal ___ 066
Int. DX *
JS & A *
Jameco ___ 333
Jan ___ 067
Jensen ___ 293
Jones ___ 626
Kantronics *
Kenwood *
Klaus ___ 430
L-Tronics ___ 576
Long's ___ 468
Lunar ___ 577
MFJ ___ 082
MIL ___ 795
Madison *
Microwave Filter ___ 637
Oak Hill Academy A. R. S. *
P.C. Elec. ___ 766
Palomar Eng. *
RCA Distr. ___ 782
Callbook ___ 100
Constructor *
Radiokit ___ 801
Radio World *
Ramsey ___ 442
Sem Con ___ 808
Sherwood ___ 435
Slep ___ 232
Space ___ 107
Spectronics ___ 191
Spec. Int. ___ 108
Swan ___ 111
T. C. I. ___ 785
TEDCO ___ 791
Telrex *
Ten-Tec *
Tropical Hamboree *
Vanguard Labs ___ 716
Varian ___ 043
Webster Assoc. ___ 423
Western *
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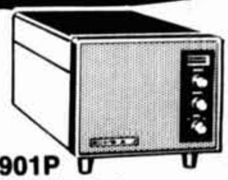

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